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ABSTRACT

Over the past 2 decades the usefulness of the computer in science and education has been demonstrated by the rapid growth of applications. Striking advances have been made in data analysis and research through its use; however, in the direct application of computers to the instructional process, obstacles still exist between promise and fulfillment. This study seeks to identify those obstacles that have hindered the development and acceptance of computer use in instruction, and to suggest means for overcoming them. The Delphi Technique was used to obtain and analyze the judgment of educational practitioners, theoreticians, hardware and software specialists, and evaluators on (a) major impediments to wider use of computers in instruction, and (b) actions that might increase acceptance and use of computer-based instructional materials. (Author)

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FACTORS INHIBITING THE USE OF COMPUTERS IN INSTRUCTION

Ernest J. Anastasio
and
Judith S. Morgan

A Final Report to the National Science Foundation

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EDUCATION & WELFARE
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STUDY OF FACTORS THAT HAVE INHIBITED A MORE WIDESPREAD USE OF COMPUTERS IN THE INSTRUCTIONAL PROCESS

Ernest J. Anastasio
Judith S. Morgan

FINAL REPORT

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Washington, D.C.

Principal Investigator: Ernest J. Anastasio
Educational Testing Service
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1972

PREFACE

Over the past two decades the usefulness of the computer in science and education has been demonstrated by the rapid growth of applications. Striking advances have been made in data analysis and research through its use; however, in the direct application of computers to the instructional process, obstacles still exist between promise and fulfillment.

This study seeks to identify those obstacles which have hindered the development and acceptance of computer use in instruction, and to suggest means for overcoming them. The Delphi Technique was used to obtain and analyze the judgment of educational practitioners, theoreticians, hardware and software specialists, and evaluators on (a) major impediments to wider use of computers in instruction, and (b) actions that might increase acceptance and use of computer-based instructional materials.

The results of the project are suggestive rather than definitive. They do *not* represent a conclusion by the panel as to what should be done to further acceptance; they *do* indicate likely sources of difficulty and promising steps for resolving them which the project participants believed should be considered in planning for the future growth of computer use in instruction.

The report is organized so that a summary overview of major points can be found in Chapter III and a general interpretation of the findings in Chapter V, following the main body of results.

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We wish to express our special appreciation to NSF personnel, especially to Arthur Melmed, for the help and guidance given us in working out details of the study objectives.

The efforts and cooperation of the project participants, in all phases of the study, are gratefully acknowledged.

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Chapter I

Statement of Problem

Considerable manpower and extensive fiscal resources have been expended in recent years to investigate the value and cost of computer use at all levels of the educational process. The National Science Foundation, through its Office of Computing Activities, has supported several of these investigations, most notably in the areas of computer applications, user services, and training. The specific areas of computer applications that received substantial attention were (a) use of computers in problem-solving situations, (b) model development and simulation, and (c) computer-aided and computer-managed instruction. Studies of user services compared and evaluated local versus remote processing, batch versus interactive processing, and cost benefits gained from economy of scale versus cost of the new generation of mini-computers. Studies in the training area examined the impediments to, and costs of, training faculty in computer use, and looked at the problems and costs of developing and distributing computer-oriented and computer-based curricular material.

Certain aspects of these investigations are of particular concern because they have been especially troublesome to evaluate. Probably the major difficulty has been that, despite evidence of the computer's value for instructional uses, the educational community is still reluctant to accept it. A reflection of this reluctance is that few educators are developing quality course materials to support instructional applications of the computer. In addition to this lag in authorship, there are the problems of unexpectedly high costs for developing materials and the total absence of mechanisms for distributing materials that have been developed.

Many explanations have been offered to account for these conditions. For example, some observers suggest that inadequate incentives for authors are a major reason so little faculty effort has been spent on developing computer-based materials. Others see the relatively primitive and cumbersome "author languages" as contributing to the discouragingly high costs of development. Still others view low volume, limited experience in packaging and marketing, and the fear of nonrecoverable costs as factors that account for the missing distribution mechanisms.

Numerous additional difficulties have been cited as root causes for the lack of widespread use of computers in instruction. The present study was undertaken to identify the most plausible explanations of this multifaceted problem and to outline strategies for overcoming the difficulties.

Chapter II

Research Plan

The study was designed to be conducted in two phases. The first phase was a questionnaire survey that, through the Delphi Technique, gathered (a) opinions about the major obstacles to acceptance of computers in instruction, and (b) suggestions of actions or plans for overcoming the obstacles. The second phase was a conference whose purpose was to bring the participants together to discuss aspects of the action plans, such as cost, need, and social and technical feasibility, and to express opinions as to which plans were most worthwhile to pursue.

Definition of CAI

Throughout the study, computer-assisted instruction (CAI) was used as a generic term, comprising all aspects of computer use in an instructional context. Included within the scope of the term was what some have preferred to call computer-based education, and also problem-solving, gaming, simulation, etc. This point was noted on the cover page of each questionnaire.

The Participants

Because computer use in education cuts across a number of disciplines, the project participants were selected from several areas of specialization, including curriculum development, educational research, educational administration, law, computer and systems science, computer hardware and software, publishing, and communications regulations. Invitations to participate were extended to 42 authorities in these areas, 34 of whom accepted. Of this group, 30 completed the questionnaire phase, and 20 attended the conference that closed the data-gathering sequence.

The distribution of the 30 participants among the several areas of specialization was as follows:

Curriculum Development: two directors of commercial instructional materials companies, a director of a research center specializing in the design of instructional materials, and a university researcher concerned with the development of authoring techniques and programming languages.

Educational Research: a director of research for an educational research institute, three directors of university CAI labs, and two researchers specializing in educational evaluation.

Educational Administration: a superintendent of a large metropolitan school system, an ex-superintendent now president of an educational research firm, a foundation president, an administrator of a national educational association, and a university administrator.

Law: a professor of law specializing in copyright infringement and related legal issues arising from applications of new technology.

Computer and Systems Science: a psychologist and a social scientist who have served as advisers to the government on the integration of technology into education, and three computer scientists specializing in computer applications in education.

Computer Hardware and Software: two representatives of large hardware manufacturing firms, and two university professors representing major computer centers.

Communications Regulations: a former commissioner of a communications agency.

In the first questionnaire, 12 categories of CAI-related activities were presented and respondents were asked to check those areas in which they had had experience. To give an idea of the range of participants' backgrounds in terms of CAI, the number of respondents checking each category is listed in Table 1.

Table 1

Respondent Experience

	Category	*Number Who Checked*
1.	Administration of CAI lab	7
2.	Administration of computer center	6
3.	Designing of software	17
4.	Software development	18
5.	Designing of hardware	9
6.	Hardware development	11
7.	Recordkeeping function of computer	10
8.	Design of computer-based curriculum	12
9.	Structuring of curriculum content	14
10.	Evaluating computer-based curricula	12
11.	Training educators in use of computer-based materials	13
12.	Teaching with computer-based materials	14

Delphi Technique

The Delphi Technique is a method for the systematic collection of expert or informed opinions. The purpose of the procedure is to obtain a consensus without bringing the experts together in a face-to-face meeting;

this is achieved by having them complete a series of questionnaires interspersed with controlled opinion feedback. Not only can the process mean a saving in money, but also, and more importantly for this study, the mode of controlled interaction encourages independent thought and the gradual formation of thoroughly considered opinion. It has, moreover, the advantage of providing anonymity to participants. These characteristics give the Delphi Technique a distinct advantage over the traditional faculty or committee meeting, where direct confrontation in too many instances prompts the formulation of hasty and preconceived notions, an inclination to close one's mind to novel ideas, or a tendency to be influenced by the loudest or most persuasive speakers, regardless of the substance of their argument.

Questions appropriate for consideration through the Delphi Technique are those on which mature and informed judgment must be exercised rather than those that lend themselves to analytic solutions. For instance, the technique is useful in complex situations such as prediction-making where conclusions are necessarily based on intuitive judgment or insight. Greatest success with the technique is generally obtained when the contributed opinions are based on thorough knowledge and pertinent experience, and when participants are given the opportunity to make their own logical structures and to synthesize what they both know and feel into an appropriate form.

In summary, the advantages of the Delphi Technique for this study were these:

(1) The technique assured each participant substantial opportunity to contribute his opinions.

(2) The procedure could take advantage of multiple types of relevant information, since it could sample the knowledge and values of experts in diverse fields and disciplines.

(3) The technique allowed a select body of authorities to deal with values as well as with facts, with impunity.

(4) The technique allowed participants to address, systematically, the key issues regarding the use of computers in instruction.

(5) Through the use of successive questionnaires, it was possible to arrive at a careful identification, definition, and evaluation of basic problems of demonstration, cost, development, and distribution of computer-based curricular materials.

The Delphi Technique is generally applied as follows: (a) the participants are asked to list their opinions on a specific topic, such as scientific predictions or recommended activities; (b) the participants are then asked to evaluate the total list by a criterion, such as importance, chance of success, etc.; (c) each participant receives the list and a summary of responses to the items – if in the minority he is asked to revise his opinions or indicate his reasons for remaining in the minority; (d) each participant again receives the list, an updated summary, and the minority opinions in a final opportunity to revise his opinions.

Questionnaire Sequence

The initial phase of the study was conducted with three general aims in mind. The first was to have the participants briefly outline their views of general educational goals and of the use and value of the computer in implementing these goals. The second was to identify factors that have inhibited widespread use of computers in instruction. The third was to produce plans for future action.

A sequence of three questionnaires was used to achieve these aims. Each of the questionnaires focused on the same three major questions:

(1) In what ways do you believe the use of computers in instruction would improve the educational process?

(2) Why have computers not been more widely used in the instructional process?

(3) What needs to be done to tap more fully the potential contribution of the computer to the instructional process?

The Delphi Technique proved effective in producing convergence on the major issues involved in these questions. A more detailed description of the substance and logic of the questionnaire sequence is given in Chapter IV. Copies of the questionnaires are shown in Appendix 1.

Conference

To conclude the process of gathering and refining data, a conference was held. Its purpose was to focus on orientations for action that could overcome the obstacles to CAI acceptance delineated in the questionnaire sequence. To this end a series of "mini-Delphi" exercises were devised which were to continue the Delphi format of information feedback and opinion refinement. Theoretically these were to combine the advantages of the Delphi Technique, described above, while providing opportunity also for structured "face-to-face" discussions.

The data on which the conferees were to work were 83 "action statements." These were derived from the questionnaire responses and were reduced to a single sentence for easy manipulability. Both the original action suggestions and the action statements are included in Appendices 4 and 5. The end product of the conference was to be a rough ranking of the items in terms of "worthiness for additional consideration," with the top half or so of the items receiving further detailed evaluation of cost effectiveness and feasibility in workshops. There were to be several iterations of ratings of the top items, culminating in the allocation of a hypothetical five-year budget directed toward advancing the growth in value and acceptance of CAI.

The sequence was to be as follows:

First Session: The group rates the 83 statements on a 0-3 scale.

Second Session: The bottom two-thirds of the ranked list are considered; items not voted in are dropped; new suggestions voted in are added.

Third Session: Workshop A - rates items on general feasibility; discusses future technological developments and breakthroughs that might affect

cost and prepares statements on these. Workshop B – rates items on cost effectiveness and discusses those where there are divergent ratings; splits into subgroups which define cost parameters of each item.

Fourth Session: Workshop A - discusses, rates, and prepares statements on any especially negative features of items in relation to special-purpose or "stakeholder" groups in education (e.g., handicapped students, teachers, vocational trainees).

Workship B - estimates cost of items using the prepared cost parameters as guidelines; discusses and rates any especially positive values of items in relation to educational "stakeholder" groups.

Fifth Session: The material summarized from the workshops is distributed and discussed; the conferees individually allocate a limited budget among the items, in separate "Research and Development" and "Action and Implementation" programs.

This series of exercises, however, did not work out as planned. In fact, the course of the meetings bore little resemblance to the intended progression of inputs and evaluations. From the very beginning of the conference, the structure was questioned and even adamantly opposed by some of the conferees. This was due in part to misunderstanding, in part to the rigidity of the planned procedure, and in part to a fundamental problem which was symptomatic of organizational difficulties encountered throughout the study.

The misunderstanding ensued from a feeling that the planners had made some arbitrary assumptions and that the organization was not appropriate. Rather than serving as a minimally constraining framework for the conferees to interact within, as was intended, the format appeared to a number of conferees to be an interpretation with which they had to agree or disagree at the outset. Some participants felt their viewpoints could not emerge in such a framework, or be given enough weight. This was true in the sense that the planning of the conference was oriented much more toward gaining a consensus than toward exploring areas of divergence.

The rigidity of the procedure lay in the fact that it tended to channel the conferees – all highly articulate, experienced specialists with very definite opinions – into limited, structured interactions. The conferees were more inclined to a format of free discussion, and, in the end, unstructured interaction formed the major portion of the conference proceedings.

The third contributing factor to the conference difficulties pertains to the whole study, and is discussed below.

Organizational Difficulties

The fundamental problem underlying the conference organization is evidenced throughout the report. The area of CAI acceptance cuts across a broad range of technical, economic, and educational issues. This of course is what makes the area so difficult to analyze and evaluate. In order to gain the general view that was the object of the study, the participants were drawn from a number of fields representing this range. This inevitably resulted in a fragmentation of expertise which made it difficult throughout the study to approach problems with a common orientation. For instance, school administrators thought of CAI in terms of elementary-level drill and

practice, university professors thought of college-level applications, publishers thought in terms of marketable forms, etc. It was clear from the responses to the first questionnaire that occasionally some groups of participants were reacting on totally different planes than other groups. In the conference discussion, emphasis was continually shifting back to the problem of gaining a unified perspective that would be satisfactory for the majority of conferees.

The following characteristics of the study stem from this fact:

a) The Delphi Technique had to be slightly altered. Since interpretation of a particular questionnaire item varied widely depending on the expert's field, it did not seem reasonable to place emphasis on obtaining convergence of item ratings. Instead, the orientation was shifted toward gaining information on the overall viewpoints of the respondents, particularly in the third questionnaire. Of course, the essential feature of the Delphi Technique, in feeding back information and receiving reevaluated responses, was useful in getting an overall delineation of where the strong divergences in viewpoint were.

b) In terms of the conference, this fragmentation meant that all the participants were not looking at the conference design in the same context. They disagreed with each other as well as with the planners, and, in the process of articulating their positions, became much more interested in the nature of their disagreements than in reaching any consensus of views. Interesting discussions emerged, of course, but not in clear-cut, readily summarizable form. As a result, as some of the conferees themselves suggested, the authors have opted to work the conference discussion into the report in the loose, subjectively stated way described below.

c) The dominant opinion in a particular area – e.g., in education – may have come from a subgroup of respondents involved in that area, because it is only this group which has commented substantively on the topic (or, at the conference, discussed it). The other participants, less familiar with the area, remained silent and, in effect, tacitly endorsed the view. In other words, some of the opinions that are presented as representative of the group were discussed by relatively few of the participants, namely, those who had something to say about them.

d) The overall picture that the report draws is dependent on the distribution of participants among fields. That is, it is possible that if more computer science experts had been included, the report's section on "Technical Research and Development" would have been expanded.

Organization of the Report

The bulk of the results are drawn from the comments made by questionnaire respondents and from the transcripts of the conference discussion. Quantitative data from the questionnaires are described in a few instances, as well as summarized in the appendices. However, for the reasons already described little emphasis was placed on the specific rating values attached to the questionnaire items. Instead, the authors have tried to present a picture of impressions that reflects as accurately as possible

the agreements, considerations, disputes and inconsistencies that emerged from the soft data, and that give the "best fit" to the hard data.

It was, of course, obvious that particular points of view were endorsed much more strongly by the group than others, which is useful information even though it derives from subjective evaluation. Consequently, a rough index is used in Chapter IV to indicate the degree of agreement surrounding the issues discussed, as follows:

*** - high degree of consensus; essentially all participants agreed on this point

** - moderate consensus; most participants agreed, without a significant dissenting view emerging

* - limited consensus; some but not most participants agreed, without a significant dissenting view emerging

Except where points of disagreement or pertinent questionnaire data are described, the report consists of what we judge to be the dominant viewpoints, written as though by a hypothetical participant whose opinions consistently aligned with the general opinion of the group.

Chapter III

A Summary of Results

For the convenience of readers who do not wish to explore the details of the questionnaire rounds and the conference, this chapter briefly summarizes the principal findings. Comprehensive findings then follow in Chapter IV, and in Chapter V the authors have added their own analyses and a brief discussion of the suggested plans of action.

The complex factors inhibiting widespread use of computers in instruction have three principal dimensions – educational, economic, and technical. These three dimensions are reflected in the six categories into which opinions were grouped: (a) production and distribution of instructional materials, (b) demonstration of the effectiveness of CAI, (c) theory of instruction (need for additional psychological and educational research), (d) educational system and the teacher, (e) cost, and (f) technical research and development.

Out of the cumulative Delphi process of questionnaires and the final conference of participants, the educational dimension – i.e., the problems related to the availability of adequate materials and the lack of evidence of CAI effectiveness – was judged to be the most critical. Almost as critical is the economic dimension, although the solution to the problem of CAI's high costs was thought to probably depend on already existing market pressures which are bringing costs down. The technical dimension, which is mainly concerned with creating adequate CAI delivery systems, was judged not to be of critical importance.

In category *a* – production and distribution of instructional materials – the respondents singled out obstacles related to lack of faculty interest in, diffusion of responsibility for, and lack of incentives for the development and distribution of computer-based materials. The lack of good, readily available computer-based educational materials was the most highly rated item in the study. The scarcity of materials results from a lack of established production methods and procedures, lack of professional and economic incentives, and the vagueness of market prospects. Opinion converged toward the following majority view: A market should be established with federal backing or incentives, and this market could be expected to become self-supporting, especially if new uses – simulation, gaming, problem-solving – were developed. Guidelines for standardization, flexible royalty and copyright policies, and appropriate production models

(particularly team-oriented approaches), are also needed to encourage the growth of a strong market for materials.

In category *b* (demonstration), the fact that there are few examples of effective CAI use was judged to be a major problem. Two opposing viewpoints became evident. One held that large-scale demonstrations of educational effectiveness are needed, but not in the context of status-quo education. CAI must improve education, without undue concern for economic feasibility – educational revision should be a national goal. The opposing opinion was that CAI should be developed just like any other instructional medium; i.e., it only needs commercial incentives to improve it, though federal support will be necessary initially. Participants agreed that the teaching of basic skills, e.g., English and math, would be a good initial target in demonstrating successful applications of CAI. Specific uses recommended were: remedial programs for the disadvantaged; curriculum development within a discipline; courses for community colleges and lower-level undergraduates; education for the handicappped; and vocational, industrial and military training.

In category *c* (theory of instruction), it was agreed that there is a need to gain deeper understanding of CAI's unique instructional capabilities. The computer's information-processing potential is far from being fully utilized in present CAI systems. Aspects of CAI that should be explored in this regard are: the need for new production techniques integrating CAI's programming, display and documentation requirements; the great range of roles from information resource to tutor that CAI can assume; instructional applications of simulation, gaming and process teaching; the potential for individualizing learning sequences; and the use of CAI in a research mode. In addition, our knowledge of the instructional process in general has to be extended and applied to CAI design. This may not involve further direct efforts in learning theory research, but rather may come from new experimental techniques arising from the research use of CAI itself.

Broad use of CAI will require changing the traditional role of the teacher (category *d*). This may be a major source of educational resistance and must be resolved by effective teacher training and by careful planning of CAI systems to support a new role for teachers. Unless this new role is attractive to teachers, it will not be accepted by them. Additional resistance may stem from seeing CAI as a job threat, as an attempt to automate education, and as another in a series of technological aids that have failed to fulfill initial expectations. However, the majority felt that if CAI can be shown to meet concrete needs, teachers will more readily adopt it. To this end, demonstrations must be combined with careful, honest and critical evaluations that convincingly indicate the effectiveness of CAI applications. These evaluations should entail more rigorous cost effectiveness analyses, specification of goals, and measurement of instructional effectiveness. Such evaluations will help provide a basis for systematic improvement of educational methods.

The participants agreed that the problem of high costs (category *e*) is an important one. However, it was felt that normal commercial pressures in already existing markets will do much more to bring down costs than any

extra effort made for educational applications. It is more important at present to concentrate on difficulties that are specifically educational: specifying course objectives so that cost effectiveness can be measured, and developing appropriate accounting methods. The cost problem will probably be worked out first in colleges, which have fewer restrictions in allocating funds and reordering priorities, and which are most likely to have access to computer installations.

Problems of technical research and development (category *f*) were judged to be less important than educational and economic problems in inhibiting widespread use of the computer in education. The most significant problems were considered to be the need to improve the reliability of hardware and the design of student terminals. There was sharp disagreement about the necessity of improving the computer's ability to accept free-form responses from the student. For those who saw CAI as ultimately assuming a "Socratic" or tutorial role, this was considered critical; for those who did not see this role for CAI, it was unimportant. Programming languages were judged not to be a significant problem.

During the conference that completed the research process, the participants evaluated a number of action statements that had been suggested for encouraging more widespread use of computers. The 15 on which there was the most agreement are presented below.

A. Research and Development

Learner control/learning styles. Develop systems that allow more learner control of the material and of the style of teaching.

Educational terminal (graphics/audio). Organize a team of industrial designers, engineers, teachers, and students to develop one or several educationally oriented computer terminals.

Learning theories. Develop a foundation of theories of learning and experimental data which would enable the computer to be maximally flexible and effective in teaching, as opposed to being a page-turning and response-recording device.

Software format. Establish a format for the production of software that will make it usable in a variety of hardware systems.

Cooperative/competitive. Develop programs in which the student questions the computer rather than the reverse (cooperative rather than competitive use of the computer in a learning situation).

Model town. Set up a large-scale model demonstration of CAI-in-the-home in a new town (200 new towns are now in some stage of planning or construction in the U.S.).

Learning styles. Develop the capability to identify and match student learning styles in different content areas with appropriate pedagogical techniques.

B. Action and Implementation

Simulation and gaming. Concentrate curriculum development efforts on utilization of the computer's unique capabilities, e.g., in problem-solving exercises, simulation, and gaming.

Support teachers in CAI development. Identify teachers who are good writers and who have classroom experience in computer applications and support them in the writing, publishing, and distribution of quality curricular materials.

Summer workshops. Institute summer workshops to provide teachers with hands-on experience with available CAI systems.

Model schools. Set up one or more CAI-based model schools (elementary schools, high schools, or college campuses).

Cooperative project. Implement a cooperative project involving a community college system and a major commercial producer of educational materials to develop, test, and demonstrate a remedial course, such as remedial English.

Large-scale demo. Mount a large-scale experiment to demonstrate the economic feasibility of CAI.

Finance teaching of CAI techniques. Finance teacher training institutions to include practical training in the use of hardware and software, and in the techniques of integrating CAI with the traditional education process.

Professional ineentives. Establish professional incentives for university faculty through a grant program that requires from the recipient university assurance that work on CAI development would be judged equivalent to research, in terms of promotion, salary, etc.

The list comes from what was intended to be the final budget allocation exercise culminating the workshop evaluations of feasibility, cost-effectiveness, and special benefits. However, the conferees objected that such an allocation could be misconstrued as being far more conclusive and significant than was actually the case, especially since the action statements did not include any details of implementation. Consequently, it was agreed that the allocation figures would not be published. Instead, the list of 15 action statements simply consists of those statements which received the greatest number of allocations, irrespective of the size of the allocation.

Chapter IV

Comprehensive Discussion of Results

This section contains a description of the questionnaire sequence, and extended discussion of the substantive results that emerged from the study.

Question One

The first major question required participants to estimate the desirability of, and the computer's potential contribution to, a number of presumed educational benefits that might result from the use of computers in the instructional process. This section was planned simply to derive a working frame of reference as to what the group anticipated would be the desirable outcomes and potential contributions of a wide-spread instructional use of computers. Consequently, after the first questionnaire had obtained a rough degree of unanimity, attention was directed much more heavily toward the other sections, giving responses to this first question only a slight degree of further refinement.

The first questionnaire presented 11 items for consideration. Respondents were asked to supplement these with any other educational improvements they thought significant. Seventy-two additional items were received from this round. From these were chosen three improvements that were most frequently suggested; these were presented for rating in the second questionnaire. The third questionnaire presented all 14 items in rank order and asked for comments wherever a respondent disagreed with any evaluation.

Response to the first question was clear and generally uniform. There was substantial agreement that where adequate facilities and quality course materials are available, subject matter can be taught more rapidly, meaningfully, and thoroughly with the computer's aid. In general, the group's opinion was that the proper use of computers in instruction would make education more productive and effective, allow for greater individualization, and provide for greater equality of educational opportunity.

There was also strong agreement that computers could make their greatest contribution to the instructional process by enabling students to interact with systems of realistic complexity; e.g., in the physical, social, and behavioral sciences, and in business, engineering, and medicine.

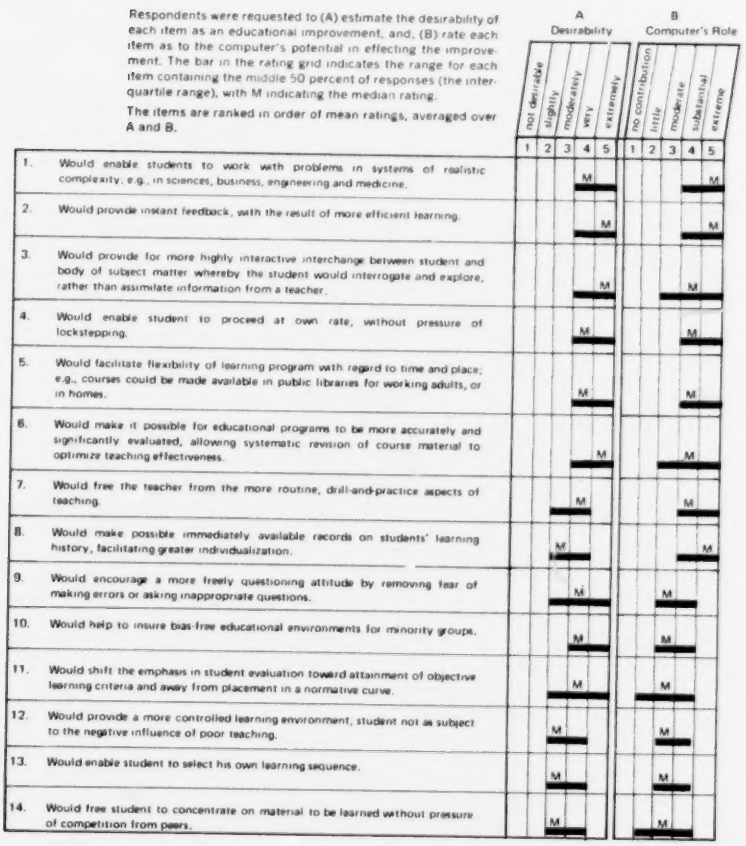
Several other direct educational benefits were identified. For example, because they can provide r. ore immediate feedback, computers in instruction may afford more efficient learning and perhaps help produce more highly motivated students. Also, more widespread computer use might provide greater flexibility in scheduling learning programs; e.g., courses could be made available in public libraries, dormitories, or homes. Ratings of these and other opinions on the ways computers could be used to improve the educational process have been summarized in Table 2.

TABLE 2

Response to the first question: "In what ways do you believe that the use of computers in instruction would improve the educational process?"

Respondents were requested to (A) estimate the desirability of each item as an educational improvement, and, (B) rate each item as to the computer's potential in effecting the improvement. The bar in the rating grid indicates the range for each item containing the middle 50 percent of responses (the interquartile range), with M indicating the median rating.

The items are ranked in order of mean ratings, averaged over A and B.


A
Desirability
not desirable
slightly
moderately
very
extremely
1 2 3 4 5
B
Computer's Role
no contribution
little
moderate
substantial
extreme
1 2 3 4 5
1. Would enable students to work with problems in systems of realistic complexity, e.g., in sciences, business, engineering and medicine.
2. Would provide instant feedback, with the result of more efficient learning.
3. Would provide for more highly interactive interchange between student and body of subject matter whereby the student would interrogate and explore, rather than assimilate information from a teacher.
4. Would enable student to proceed at own rate, without pressure of lockstepping.
5. Would facilitate flexibility of learning program with regard to time and place; e.g., courses could be made available in public libraries for working adults, or in homes.
6. Would make it possible for educational programs to be more accurately and significantly evaluated, allowing systematic revision of course material to optimize teaching effectiveness.
7. Would free the teacher from the more routine, drill-and-practice aspects of teaching.
8. Would make possible immediately available records on students' learning history, facilitating greater individualization.
9. Would encourage a more freely questioning attitude by removing fear of making errors or asking inappropriate questions.
10. Would help to insure bias-free educational environments for minority groups.
11. Would shift the emphasis in student evaluation toward attainment of objective learning criteria and away from placement in a normative curve.
12. Would provide a more controlled learning environment, student not as subject to the negative influence of poor teaching.
13. Would enable student to select his own learning sequence.
14. Would free student to concentrate on material to be learned without pressure of competition from peers.

Questions Two and Three

The second major question asked respondents to evaluate the problems that have kept CAI from being more widely developed and accepted. In the first round, a list of 23 possible obstacles was presented and respondents were asked to rate these and suggest additional items. From the 49 additional items that were returned, 16 were added in the second questionnaire and were rated along with the old items, which were organized into categories. In the third questionnaire the list was presented again for rating, in category format. Within each category the following two questions were asked:

> Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)
>
> Do you feel that the nature of the problems in this area differs significantly for different levels of education (e.g., precollege and college)? If so, how?

A few representative comments that touched on key issues were also presented in each category for the respondents to agree or disagree with.

The third major question requested suggestions for overcoming the obstacles identified in Question Two and for facilitating the growth, in value and acceptance, of CAI in the future. The 80 suggestions received from the first questionnaire were edited and reduced to 38 items, organized into categories, and presented in the second questionnaire for ratings. In the third questionnaire, the three most highly rated items in each category were presented, and the respondents were asked "Are there other suggestions that you believe are more important than these?" In addition, in a final section of the third questionnaire, the respondents were requested to outline two or more action plans, based on one of the three suggestions in each category, or any additional idea they felt was worth exploring. These action plans are presented in original form in Appendix 4. They provided most of the 83 action plans considered at the conference.

The sequence used was not a strict Delphi application. It soon became clear that CAI has too many dimensions for a simple iteration of rating refinements to achieve the substantive overview that was the goal of the study. The sequence did, however, stay within the spirit of the technique in feeding back inputs for clarification and sharpening of focus.

Some convergence was obtained in the item-rating of obstacles (see Appendix 3). It is interesting to note that the Questionnaire 2 ratings, in which the Questionnaire 1 data were presented in bar-graph form and a simple rerating was requested, did not converge significantly. That is, respondents were not moved to change their ratings by seeing the group data. With Questionnaire 3, however, respondents were asked to comment wherever their final rating fell outside the interquartile range of group responses for each item. Here there was substantial convergence, as would be expected. Evidently, feeding back group data, without requiring an explanation for disagreement with the majority, does not result in a refinement of consensus.

The responses to Questions Two and Three were numerous and diverse. So that these could be more effectively considered, they were grouped into categories. The objective in selecting the categories was to reduce the effort required of the respondents by providing a degree of organization while superimposing only a minimally artificial structure. The six categories finally settled on, after some revision during the sequence, were these:

(a) Production and Distribution of Instructional Materials
(b) Demonstration
(c) Theory of Instruction
(d) Educational System and the Teacher
(e) Cost
(f) Technical Research and Development

In the following discussion of results, the questionnaire data, conference dialogue, and action plans are interwoven in a description of the overall issue of CAI acceptance as seen by the project participants. The report is written in such a way as to reflect what seems to be the generally held opinions, while making distinct the issues that provoked disagreement. The attitudes expressed are not the authors'; rather they indicate what the authors feel were the group's views. The discussion is organized into the categories listed above, with a brief introduction to each describing general areas of agreement and disagreement.

A. Production/Distribution of Instructional Materials

Obstacles identified in this category grouped themselves as problems of lack of interest in, diffusion of responsibility for, and lack of incentive for the development and distribution of computer-based materials. Table 3 displays specific factors relating to the production and distribution of instructional materials that were judged to be significant impediments to widespread computer use.

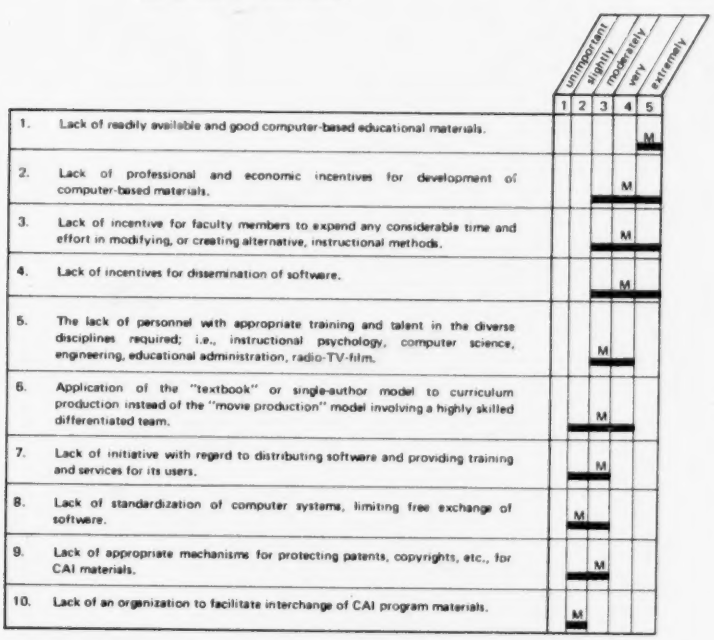
There was substantial agreement that the inadequate supply of effective instructional materials was the most serious short-term obstacle to widespread use of computers in the instructional process. The problem which received the highest ratings in terms of importance in the entire questionnaire was Item 1: the lack of good, readily available computer-based educational materials. The consensus of the group was summarized by one respondent: "Adequate course materials seem to be the key variable. Hardware is now available, and improvements will be made continually. However, course development is slow and needs far more attention. The quality of CAI will be determined by the quality of the materials inserted into the computer."

The reasons for the scarcity of good materials are complex and interrelated. Generally, they have to do with the lack of established production methods and procedures, the lack of professional and economic incentives, and the vagueness of market prospects. It was the majority view that a market must be established, initially with federal backing or incentives, but eventually self-supporting, and that attractive and marketable new uses

TABLE 3

Production/distribution of instructional materials. This category dealt with problems of interest, responsibility and incentive in the development and distribution of computer-based materials. The first item, "lack of readily available and good computer-based educational materials", was the most highly rated item in the study.

The bar in the rating grid indicates the range for each item containing the middle 50 percent of responses (the interquartile range), with M indicating the median rating. The items are ranked in order of mean ratings.


unimportant
slightly
moderately
very
extremely
1
2
3
4
5
1. Lack of readily available and good computer-based educational materials.
2. Lack of professional and economic incentives for development of computer-based materials.
3. Lack of incentive for faculty members to expend any considerable time and effort in modifying, or creating alternative, instructional methods.
4. Lack of incentives for dissemination of software.
5. The lack of personnel with appropriate training and talent in the diverse disciplines required; i.e., instructional psychology, computer science, engineering, educational administration, radio-TV-film.
6. Application of the "textbook" or single-author model to curriculum production instead of the "movie production" model involving a highly skilled differentiated team.
7. Lack of initiative with regard to distributing software and providing training and services for its users.
8. Lack of standardization of computer systems, limiting free exchange of software.
9. Lack of appropriate mechanisms for protecting patents, copyrights, etc., for CAI materials.
10. Lack of an organization to facilitate interchange of CAI program materials.
M

of CAI, such as simulation, gaming, and problem-solving, should be developed. There was, however, some feeling that this was essentially a "stockholder" approach, with its emphasis on commercial development of CAI, and that such a limited viewpoint does not meet the magnitude of the educational problem, nor the urgency of the need for change.

Within this first category (Production and Distribution of Instructional Materials), the major concerns can be grouped under the following headings: new directions, the author, incentives, the market concerns of the publisher and of hardware and software manufacturers, market development, production models, royalty and copyright, standardization, and national organizations. Specific concerns in regard to each of these items are summarized as follows.

New Directions

More imaginative, effective, and marketable forms of CAI need to be developed*** (see Section C, Theory of Instruction, for further commentary). Overemphasis on tutorial and drill and practice applications, and insufficient emphasis on other instructional strategies, have had a stultifying effect on CAI's growth. Consequently, computer use in education will be strictly limited until new and striking areas of exploration are identified and developed. One promising direction for effort is the area of simulation and gaming, an area in which the computer provides capabilities that cannot be duplicated by any other instructional means. Comparatively little has been done to enhance the computer's use in this area. The creation of effective simulation and gaming materials should be a major goal in developing a substantial and viable CAI market, and in furthering CAI acceptance.*** (See Tables 2, 3 and 5.)

The Author

In the third questionnaire the following question was asked of the participants: "Who are most likely to be the primary producers of CAI course materials?" Only brief responses were requested, but the answers serve to indicate the general orientation of the group in approaching the problem of author incentives. Of those responding, seven named university or college faculty as the most likely authors. Seven others listed the private sector – i.e., publishers, instructional-materials houses. Several in this group added that CAI materials would be produced in the same way as textbooks, but with experts in production techniques to backstop the authors. Six of the remaining responses focused on various team approaches to materials development. (See Appendix 2.)

Incentives

A significant problem, particularly at the level of higher education, is the absence of economic and professional incentives for designing, developing, and distributing CAI materials.*** (See Item 2, Table 3.) Incentives are particularly important at the university level, where there is the greatest potential for development of materials, as noted above. At the university level the lack of professional incentives stems from the general disinterest in improving teaching methods (Item 3, Table 3). Current academic incentives practically ignore the development or improvement of instructional techniques. Thus the participants generally agreed that more resources should be directed toward recognition of technological applications in education and toward revising the academic reward system.** Incentives comparable to those provided for disciplinary research should be made available, i.e., financial rewards, prestige, and enhancement of career. In effect, this would mean a legitimization of work in the area.

Part of the difficulty is that the production of computer-based materials is far from the point where the writing of CAI materials could be equated to the writing of textbooks. Consequently, many university faculty will have to be willing to undertake intensive, and perhaps extensive, personal education in computers and CAI techniques. This difficulty may be partially obviated by using a team approach in which the author is

supported by a technical team. Nevertheless, faculty members now derive little advancement, and indeed are often penalized, for devoting more than a fraction of their time to refining teaching methods. Progress will be retarded in developing good college-level computer-based materials, and new instructional methods, unless or until the prevailing counter-incentives are removed.*

Elementary and secondary school teachers are also affected by the absence of professional incentives for involvement in the formal development of course materials. However, as discussed in Section D (Educational System and the Teacher), they are less likely than university faculty to have the time, skills, or resources required for courseware development.

The issue of economic incentives is very different from that of professional recognition. It is not a problem of arranging appropriate incentive structures for CAI authors. Rather, it is one of determining where the money will come from to provide the incentives.* As one spokesman for the publishing industry observed, "The appropriate incentive structures are already available and are simply waiting for the market to develop. All of the techniques of payment are there. There is no lack of willingness to pay generously for the work; there is just the question of which is more practical in a given case." In other words, once there is a market supplying money to develop CAI course material in some sizable quantity, the needed materials will be developed and publishers will quickly resolve the royalty-versus-salary-versus-"something else" incentive problem. (It might, however, be noted that this reasoning is circular, since a market probably cannot be established unless good materials of demonstrated effectiveness are available to begin with. There is a further discussion of this point in Chapter V, Conclusions and Recommendations.)

Market

A market success for CAI is critically needed to catalyze public and private investment.** Investment is clearly needed by hardware companies as well as publishers or software producers. The kind of market that could give rise to such success would have to present sufficient volume for mass dissemination and should also offer low social resistance to change.* Many of the CAI programs and applications that have been developed are in advanced college-level topics and are so innovative that they do not have impact on high-volume courses. Many other CAI developments are adjunctive to the regular instructional system, representing an add-on cost rather than a replacement cost. They therefore do not promise the economic impact that can stimulate strong motivation for social changes. This issue was raised in detail throughout the questionnaire and conference phase of the study, with several significant viewpoints emerging from the interaction of the study's participants. The viewpoints of two representatives from the commercial sector are discussed below.

a. The Publisher The critical questions directed at publishers are these: a) why haven't they been induced to invest their own money in achieving CAI success? and b) what are the reasons for the relatively modest amount

of publishers' money invested in specifically CAI materials as distinguished from the very large investment in other program materials?

The answer, in large part, is skepticism about the success of CAI as an alternative teaching technique and skepticism about the likelihood of developing a viable market in the near future. Even if publishers were confident of CAI's eventual effectiveness and profitability, they would still be faced with many kinds of investment necessary at this stage of development which are not the sort of investments that commercial sale of materials can recover. For example, when a publisher is producing a conventional textbook, he does not have to invest money to find out how to write textbooks. That information is already common knowledge, and writers know how to use it. Also, the publisher does not have to invest in a marketing effort to try to persuade customers to invest in his type of product. The public – that is, the school system – already buys textbooks; the publisher need only persuade potential clients to buy his *type* of book. But if the publisher is in the CAI field, he must first work toward establishing a market for CAI products. He has to invest both in the pure research that underlies production and also the specific research and testing of his particular product. Furthermore, his marketing effort has to be addressed toward inducing the school to use CAI techniques as well as his materials. Clearly the market will not now support that level of investment.

Nevertheless, that does not mean proper financing cannot be raised. For example, the publishers might be induced to make a considerable investment, on a shared-risk basis, if comparable government or foundation support could be provided. The shared funds could be used to support the research and development necessary to establish production techniques, procedures for duplicating and disseminating materials economically, and related requisite activities such as teacher-training workshops. This would not simply be basic research on instructional technology, but rather an effort to establish, or at least prepare the groundwork for, a sizable market.

b. Hardware and Software Manufacturers A representative of a large manufacturing firm said that an impressive sum had already been spent for CAI only to confirm some very simple and, at least in hindsight, obvious conclusions. One such conclusion was that trying to design special hardware and software for educational purposes was a mistake. There is too great a gap between design requirements for education and those for business or science, and the computer market in the latter areas is already extensive and well established. Although some work may continue on specialized terminal development, manufacturers should not go out of their way to support markets that are exclusively educational.

Another conclusion was that the course material problem is more difficult than expected. It is not, as they had hoped, simply and satisfactorily resolved by an alliance with a publisher. The publisher's role typically is not to develop materials, but to scout for, edit, package, and sell them. Unfortunately, if there is no readily available source of materials, the publisher is not necessarily prepared or motivated to create it.

A final problem was that in most tutorial and drill-and-practice applications, computer-presented subject matter did not produce any better results than traditional instructional methods, nor any savings in cost. Although this might have been the fault of the material rather than the method, it led to their conclusion that such applications of CAI are, for the foreseeable future, a very poor business proposition.

It should be noted here that a majority of the participants did not concur with the manufacturing spokesman in opposing development of hardware designed especially for educational use. Rather, the lack of appropriate hardware for CAI was judged by most to be a problem.** (See Section F, Technical Research and Development.) It thus seems that when this problem is ultimately resolved it will not be through the efforts of large manufacturers, at least in the near future. The resolution, it was suggested, will probably come through small and innovative hardware companies, ready to take large risks for the market returns that could be obtained from a well-received CAI hardware system.

Market Development

Federal funding will probably be necessary to resolve the stalemate over economic incentives and to stimulate the growth of the market.** The cost of preparing materials is so high and the investment so risky that sources of substantial investment other than the government are unlikely. Clearly, authors will not be easily persuaded to devote many years of hard work developing a program that may never sell, nor will publishers be quick to accept the risk of paying authors for their time, without the demonstrable need that assures a market. The alternatives are a broad program of federal funding or a liberal federal policy regarding support for private research and development.

There were a number of suggestions as to ways in which federal financing could support the production and marketing of CAI materials. Some involved subsidizing development of instructional materials within each of the major disciplines. For example, discipline-based groupings (like the NSF-sponsored Commission on College Physics) might be established. These could draw upon prominent scholars in the discipline to develop curricula that imaginatively exploit the computer's full instructional capability. Their materials could then be offered for commercial distribution, with royalties shared by the authors, the commission, and the government. Other proposals were less concerned with facilitating disciplinary development of computer materials. One suggestion, for example, emphasized the importance of drawing in professionals of high intellectual caliber who also have a deep understanding of both computers and education. A significant problem has been the lack of persons with appropriate training and talents, as indicated in Item 5, Table 3. Because professionals with such specialized talents and broad interests are at present rare, a primary goal would be to establish research institutes and programs to attract and train them.*

There was also emphasis on forming commercial groupings and cooperative research teams to study, develop, and experiment with CAI programs.* These might be initially encouraged by government support; however, once a solid market was available, they would continue on a commercial basis. One associate of an educational computer center thought

that, instead of paying authors for developing course materials, educational computer centers might sell their services to an author-publisher team. That is, universities could be subsidized to provide technical support and computer time for curriculum development purposes. Publishers then could be encouraged to seek out authors who are talented in a particular area and to buy, at reduced rates, the required technical support services. In this case, the author could receive a royalty incentive from the publisher, and the publisher could purchase reasonably priced services without having to invest in their development himself. This procedure would be an alternative for structuring program development that provides proper incentives for authors and relieves publishers of a prohibitively high capital investment.

A participant involved in curriculum production recommended getting individuals interested in CAI design and development to incorporate as an organization. The corporation would go to the publisher for advice, for marketing services, and possibly for initial financial backing. To incorporate, of course, would unquestionably involve heavy investment, either by the development group or the publisher or both. Again, federal subsidization would probably be needed to carry the venture until the market was large enough.

Production Models

In the development of CAI materials the continued reliance on the "textbook-author" model instead of the "movie-production" model has proven to be another problem** (see Item 6, Table 3). The CAI medium is technologically complex, and a thorough knowledge of its technical capabilities is essential to full utilization. One might conceivably find talented authors who have combined expertise in presentation techniques, computer science, and academic disciplines; but such a combination would have to be rare, given the demands of specialization in any one area. Consequently, a task-force approach, deploying a highly skilled, differentiated team that divides the responsibilities of authoring, formatting, and programming, may be necessary.

To suggest such an approach is not to deny that many successful teaching projects have been designed by individuals. Indeed, most major curricular reforms, particularly at the college level, have been effected through texts produced by one or two authors, and not by large curriculum development teams. However, there was no need in these cases for extensive technical support, as there would be in CAI development.

Royalty and Copyright

Legal control of CAI materials was an issue which received discussion among several conferees (see Item 9, Table 3). The author's right to control the content of a book indefinitely is traditional in royalty contracts, but this is a tradition that the publisher cannot afford to follow when he is dealing with CAI materials. Publishers should have the right to control the program's ultimate content since they need to have the flexibility to improve instructional materials as the materials go through iterations of use. An appropriate option for the CAI author might be the prerogative to

remove his name from any revised program, while continuing to receive royalty, but not the right to control indefinitely what is in the program as it goes through the recycling process. The issue is that greater economic reward through increased royalties simply may not be sufficient incentive to the author to improve his materials; however, the possibility of periodically improving or updating materials would be attractive to the publisher.

Copyright is an issue related to the control and content of course materials. Although the project participants did not consider copyright laws to be a factor which significantly inhibits acceptance of computers in instruction, they did stress the need for a copyright structure that protects the tax, foundation, and private money invested in developing new materials. The basic need is for a flexible policy that safeguards the public interest by allowing widespread dissemination of materials generated by research, but at the same time permits varying degrees of copyright protection.*

Standardization

The issue of standardization represents a substantial obstacle to broadening the CAI market (Item 8, Table 3). It is possible that if there is not more quality control and standardization, the result will be a weak market that will not compete with other instructional materials.* Educators are already somewhat bewildered by the profusion and variety of technological aids.

The key question is whether CAI will turn out to be a relatively uniform technology that easily permits transfer of materials, programs etc., from system to system. The alternative to uniformity would be a vertically arranged organization where whoever provides hardware would also provide the accompanying software and course materials. That is, CAI systems would be sold in packages, with one company providing all requisite equipment and services for the package. Standardization, on the other hand, would permit separate and independent markets for course materials and hardware, respectively. Thus the viewpoint of those who want to see a broad-based and open market for course materials is that standardization is a logically necessary first step.

National Organizations

The problem that was of least importance among the questionnaire items (see Item 10, Table 3) was the lack of an organization to facilitate interchange of CAI materials. It was felt that there are already several publications devoted to describing the characteristics and availability of CAI courseware, and that more will appear as the production of materials increases. The limiting factor is the lack of awareness that these information resources exist.

In a slightly different context, it was agreed that more national leadership is needed to coordinate CAI development and its adoption into schools. In Questionnaire 3 (Appendix 2), 22 out of 28 responses agreed with the statement that "national centers are needed to do research, to develop resources, to study policy questions, develop strategies, etc." The

educational reforms that effective CAI use will necessitate are of a highly intricate nature and will require careful analysis and planning.

One conferee suggested that accrediting agencies might serve a leadership function in setting minimum standards for computing which would draw schools toward a broader and more effective use of CAI. However, the majority argued that this approach would encounter serious problems. It is very difficult to frame minimum standards to bring about a desired effect; it is much easier for agencies to write checklists based on such simple determinations as academic degrees held by the faculty or number of books in the library's collection. Poorly conceived criteria would hinder rather than help the development of CAI.

B. Demonstration

A persuasive demonstration of the benefits of computer-based instruction was judged to be a critically important step in gaining acceptance for CAI. There was strong agreement that there are presently far too few examples of effective CAI use. A few participants expressed the belief that the supposed resistance of the educational system and the educational market to CAI is based solely on the lack of compelling evidence that CAI is, in fact, more effective than other instructional media.

There were several points of disagreement with regard to the kind of demonstration that would be appropriate. On one hand, the following viewpoints seemed to form a logical grouping: CAI is ready now for a full demonstration in certain applications; a demonstration should not involve such a revolutionary application of CAI that dissemination would be hindered; the demonstration should prove the economic feasibility of the system so that it can be adopted directly by schools. The opposing viewpoints were these: CAI requires further exploration and large-scale experimentation before it will be ready for demonstration; CAI should be used to implement needed radical changes rather than be tailored to present systems; and demonstrations should be oriented toward proving that CAI can offer clear advantages in quality of instruction, rather than toward emphasizing its economic feasibility.

Differences seemed to stem from conflicting views as to how CAI will develop; these were similar to the divergent views noted in Section A. One view seems to be that CAI is basically another instructional medium like books or TV, particularly useful in some areas; and once a market is established, CAI will continue to develop from commercial incentives to improve it. An alternate view seems to be that education must be reoriented on a technological base so that instruction can be improved in a systematic way, as is needed in an increasingly technological world; CAI provides an exceptional means for providing such a base and should be carefully developed on a large scale with extensive long-range societal and governmental support.

Specific factors relating to the issue of demonstration that emerged in the questionnaire sequence are listed in Table 4. Topics receiving discussion were: large-scale CAI demonstrations, quality and feasibility, educational level, and likely areas for successful demonstrations. Specific concerns in regard to each of these items are as follows:

TABLE 4

Demonstration. Responses in this category pertained to the lack of a well-designed, convincing demonstration of the benefits of computer-based instruction.

		unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1.	Too few examples of high quality use.				M	
2.	Lack of compelling evidence that CAI is more effective than other methods of comparable cost.				M	
3.	Lack of carefully planned broad programs of CAI experimentation in actual school settings.			M		
4.	Failure to design curricula and systems for high-impact, low-resistance "markets" where real institutional problems can be solved.			M		
5.	Lack of "critical mass" in setting up programs.		M			

Large-scale Demonstration:

Opinion was divided on CAI's readiness for large-scale demonstration. Of those responding, sixteen agreed that "more trial and error is needed before CAI is ready for the risk of a large-scale demonstration"; 11 disagreed (see Appendix 2). While there was general agreement that a need presently exists for setting up large-scale CAI systems, some saw the effort as a means for demonstrating the feasibility of CAI; others, however, saw it as only a beginning of the kind of extensive experimentation that is needed at this stage of development.

On one side, it was felt that enough is now known about CAI for successful large-scale demonstrations to be mounted without further experimental exploration. Such demonstrations, it was suggested, should focus on a few specialized and carefully developed forms of CAI. If CAI can be successfully demonstrated in one or two important and realistic applications, it would probably be widely adopted for those uses. Once the equipment and expertise begin to appear in the schools, other applications would much more readily develop.

On the other side, a more cautious viewpoint was advanced by some participants. They agreed on the need for continued experience with day-in-day-out use of numerous terminals in a comprehensive, standard curriculum. But projects should be undertaken with a view toward exploration and development, rather than demonstration of universal feasibility. Demonstrations can become important only after several fully effective, validated programs have been developed in this way.

The idea of "critical mass" in the size and funding of a CAI demonstration is important.* When funds have been available in the past, they were typically insufficient both in amount and in duration. Yet a critical mass of resources is crucial if the full range of interlocking educational problems is to be solved. The research and development effort with a narrow focus on technology alone is by its very nature bound to be insufficient. By analogy, a space program with developmental projects limited solely to

boosters or the launching pad would never have landed a man on the moon. The full range of requirements for systems must be identified, funded, coordinated, and projected over time with "benchmarks" to measure progress, and to insure effective management. There might be several massive experiments, on this order, designed to crack the cost/quality barrier.

One respondent suggested the idea of a balance between the minimum-scale demonstration that would show an economic or educational advantage and the maximum-scale demonstration that could be adopted by traditional schools without major reorganizations. To have a demonstrably beneficial impact on a school's functioning, a CAI system would have to be used fairly extensively. At the same time, if the demonstration system were too elaborate and required schools to completely make over their established organization, it would hinder wide dissemination.*

Conversely, some participants judged such massive reorganization to be exactly what is needed; indeed, they felt that the best function of CAI might be to implement this kind of radical change.

Quality and Feasibility

There was a clear division of participants as to whether the primary orientation of CAI demonstrations at this time should be toward demonstration of high quality instruction or demonstration of economic feasibility. Those in favor of demonstrating high quality felt that cost was irrelevant. They argued that one should wait for a convincingly dramatic demonstration before considering how to achieve the same results more economically. On the other hand, those who favored a demonstration of economic feasibility felt that to be more important, especially in view of the current financial retrenchments in education. It was their belief that high quality instruction will come naturally as experience accumulates and talented persons move into the field. As long as schools cannot afford CAI, the quality of programs is of secondary importance. This division of opinion regarding cost and quality seemed to be based on some more fundamental expectations of how CAI will develop. On one side, it was assumed that equipment costs will drop because of ordinary market pressures, and that CAI will benefit from further exploration of its instructional potential. On the other side, the concern was voiced that CAI cannot even begin to take root until costs become more reasonable. As schools begin to accept the concept as well as the costs, the refinement of programs will take place automatically.

Educational Level

There are wide differences between the type and size of demonstrations likely to be successful for precollege and those aimed at college-level instruction.** Three main factors were considered: (a) Computer resources (hardware and personnel) are established and available at the college level. Their prior availability seems to lead to greater acceptance of conceptual demonstrations and willingness to build unique systems beginning with the demonstrated concepts. At the elementary-secondary level, however, a complete package must be demonstrated because of the lack of

available computer resources. This package must include a hardware system in addition to computer programs, teaching aids, materials, etc. Because such a package is expensive, the demonstration must be all the more thorough and convincing. (b) The teacher at the precollege level has only a limited control over facilities and materials, most of which are chosen by statewide boards or district administrators. At the higher education level, the individual instructor has much more control, subject primarily to financial restrictions. The implication of this difference is that initial demonstrations at the elementary-secondary level must be designed to convince administrators of the virtues of CAI; while at the university level they must convince the instructors. (c) Another important factor is that at the precollege level CAI is likely to be competitive with existing modes of instruction, displacing persons and methods, and hence provoking resistance. At the university level, however, CAI programs extend rather than replace ongoing programs, and enhance the sponsoring professor's status; hence they require less conclusive demonstrations of value.

Areas for Successful Demonstrations

Considerable attention was devoted to identifying areas in which CAI could be successfully demonstrated. In Questionnaire 3, the question was asked: "At what level or in what area of education would CAI be initially most effective and most likely to induce a widespread acceptance?" The most frequent suggestion was to use CAI in teaching basic skills, such as math and English, either at a precollege level or in remedial and introductory courses at junior or community colleges (see Appendix 2). Other suggestions that emerged from the study (several overlap the basic-skills suggestion) were: remedial programs for the disadvantaged; curriculum development within a discipline; advanced college-level uses; community colleges; education for the handicapped; and vocational, industrial, and military training.

Remedial programs were judged a particularly appropriate sector in which to invest CAI efforts.** Specialized use of computers in remedial education could provide broad subject-matter coverage to numerous students and simultaneously afford substantial justification for using educational funds for this purpose. For example, providing remedial education for urban minority children, especially in combating the reading retardation problem, could be a particularly appropriate initial use of CAI. As one respondent suggested, "major concentration should be on designing two or three alternative CAI programs aimed at this specific problem. The social needs are greatest there, and the resources for funding research and development and for actually buying and applying developed materials are greatest there. Moreover, successes in this sector would attract wide attention and lead to much fuller support for further extensions and applications of CAI." A caution was noted by one participant that if CAI were to become associated in the minds of the educator with primarily remedial education, it would run the risk of being relegated to that use in the future.

Development of high-quality computer-based courses within a particular discipline was considered a useful way to advance CAI.* Recom-

mendations were made to support the development, in one or more disciplines, of a complete curriculum that would make heavy use of the computer and other instructional technologies. For instance, a program similar to the one that resulted in the PSSC physics course might be instituted. This program would involve a single strong thrust toward a carefully designed course, with participation by interested, qualified teachers from all parts of the country, and with summer institutes for teacher training. Such an effort should entail developing high quality materials, using the best talents, and serving a specific function; the program should not be under pressure to serve a large number of students immediately.

Community colleges were considered to be an important sector for demonstration because they are newly developing and do not have traditions and long-standing practices to overcome.* CAI applications in the community college could be designed to satisfy unmet needs, rather than to displace or replace other well-established materials. Also, since community college instructors are frequently confronted with the problem of providing a substantial amount of remedial instruction, they might welcome any assistance in making such classes more effective.

Similarly, teachers at large universities might be receptive to procedures that minimized their teaching time.* Their careers, their professional prestige, and their advancement do not, in many cases, depend on their teaching accomplishments. Consequently, they might welcome any technique that enabled students to learn at least as well as they do now, with less investment of time and effort on the teacher's part. Applications at the undergraduate level would be most successful if they dealt primarily with basic factual material, in which the humanistic mystique of personal instruction is least likely to be embedded. Other successful applications at advanced levels could take the form of diagnostic problem-solving, simulation, and gaming. One might also anticipate ready acceptance of CAI in those professional areas, such as medical technology, that need continually to update, i.e., to keep current with new techniques, new processes, and new information.

Another good prospect for CAI demonstration is education for the handicapped.* The payoff has been great in past attempts to develop technological services for special education. For example, an attempt to develop CAI materials for the visually handicapped could concentrate attention upon the legibility of the display panel. This direction of research would provide benefits beyond satisfying the needs of the visually handicapped. To be able to present more information on the screen and do it more legibly would provide benefits for all forms of CAI. CAI research has not been pushed far enough forward in a number of places where it might have been very appropriately used. If attention is focused on specific problems, such as the handicapped, the net impact of those particular programs will be increased and the outcome that much more impressive as a demonstration. Adequate funds are available for research and development in special education. Consequently attempts to aid socially needy groups like the handicapped have good promise for sufficient support.

Several participants suggested the advantages of successful demonstra-

tions outside the education sector.* They noted that CAI is most frequently discussed in the context of traditional education where its use encounters the most difficult problems. To build up confidence in CAI, why not promote convincing demonstrations in types of instruction that seek to provide measurable skills in measurable amounts of time? Such applications can be found in military and industrial training, and perhaps also in the trade school curricula. Consequently, these areas seem to offer particularly promising targets for initial CAI development.

C. Theory of Instruction

The need to acquire greater understanding of the instructional process, and to use this knowledge in developing innovative and effective CAI materials, were judged to be problems of long-range importance. There was agreement that the computer's potential is far from being fully utilized in present CAI systems – in fact, in many applications the computer serves merely as a page-turning, response-recording device. The majority view maintained that more emphasis should be placed on developing the computer's many unique capabilities, and that such development would be prerequisite to demonstrating the true advantages of CAI over other instructional media.

There was disagreement as to whether such an effort to fully refine CAI techniques should involve extensive basic research in learning processes, or whether it should be on an applied level. Some participants stated that learning theory research is irrelevant to CAI design; the opposing position was that effective CAI materials cannot be created and improved in a systematic way without solid theoretical grounding. The resolution of the dispute seemed to lie in a qualified statement that current learning theory *is* generally irrelevant to CAI design, but there are areas where data collection and theoretical analysis are enormously important for CAI development, particularly the data deriving from CAI use itself.

The pertinent factors that were rated in the questionnaire sequence are shown in Table 5. As with previous categories, the diverse concerns of the participants regarding this area can be grouped in several subcategories: learning theory, unique capabilities of CAI, research use, and learner control.

TABLE 5

Theory of instruction. Responses in this category dealt with the need to adopt new and different approaches for developing effective CAI materials.

		unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1.	Failure to recognize that material must be completely reorganized and restructured if it is to be taught effectively with computer systems.				M	
2.	Inadequate development of a range of computer-based pedagogical techniques. The range might include question-answers, tutorial, drill and practice, simulations, games, problem solving modes, etc.				M	
3.	Tendency to put too much "on the computer" rather than share the presentation and testing of curriculum objectives with other instructional media.				M	
4.	Lack of experimental data and theories in learning psychology which would facilitate the design of effective CAI programs appropriate to each age level.		M			

Learning Theory

One issue that elicited a variety of opinions was the need for more basic research on the psychology of learning. It was the opinion of some that a major impediment to CAI's acceptance was the lack of theories of learning and experimental data concerning the learning process. In their absence, we have attempted instead to use computers as a way of mechanizing programmed instruction procedures that have appeared to be effective. We have not yet developed the means to use computers in different ways more appropriate to their special characteristics and abilities. Consequently, the computer's unique flexibility in problem solving, simulation, and interactive dialogue has not been fully utilized by existing CAI sequences. Continuing large-scale research needs to be conducted in order to develop and refine techniques in the areas of instructional strategy and logic of presentation.

Several participants were flatly opposed to the statement of a need for more basic research in learning theory. Their contention was that an attempt to take current theories of learning, which involve very vague and abstract models, into full account in designing programs would require far more sophisticated capabilities than are presently provided by any CAI system. Others agreed with the somewhat different view of a participant who felt that there are some very valuable areas of research, such as in problem-solving strategies, but that "research on contemporary learning has been either at the level of too great generality, or in the case of differential schedules of reinforcement, at a level of too great specificity, very useful for pigeons in drug studies, but not much use for students in the tutorial mode."

Unique Characteristics of CAI

The computer as an instructional medium is quite unlike traditional media and needs further study in some areas.** Four differences between the computer and other instructional media were particularly underscored:

1. The procedures for the development and structuring of CAI materials vary from those traditionally employed in other instructional media.
2. The computer's versatility in assuming a variety of roles offers new possibilities for improving instruction; these roles range from passive informational resource to simulated instructor.
3. The responsiveness of the computer enables it to teach a process or dynamic system through interaction with a student.
4. The diagnostic capability of the computer enhances individualization of instruction; enormous quantities of information can be exploited about the past and present performance of a particular student.

Regarding the first point, several respondents remarked that there is a need for new authoring techniques and procedures. It has of course proved necessary with any new medium (from the book through movies to television) to develop new production techniques and to train the necessary personnel; large-scale course development for CAI is certainly no excep-

tion. Some of the programming, display, and documentation techniques require the solution of problems that have not been encountered with the older media. This point should not be underemphasized. Many current applications of the computer in education have either been pedestrian or superfluous – i.e., they could well have been accomplished through traditional techniques or through relatively inexpensive, well-prepared programmed texts. Users, therefore, have been unimpressed with the outcome of such experiments and have questioned the contribution of the effort, especially in view of the considerable expenses involved. Thus, CAI developers should be engaged in more frontier work and less in gimmickry and should be concentrating on developing new methods for producing materials.

With respect to the second point, it is important to explore and develop the full range of CAI techniques*** (Item 2, Table 5). A CAI program is qualitatively quite different from a book, film, or television, in flexibility of adaptation to virtually any kind of instructional role. It can combine content and process with evaluation, decision making, and record keeping. It is potentially test, text, teacher, remedial specialist, audiovisual specialist, guidance counselor, and administrator wrapped into one coherent system. This qualitative difference raises conceptual and technological questions not met in other technology-based educational aids. For instance, it must be decided what techniques are suited for different ages, and what orientations are most beneficial for the student in the long run. One minority view related to this point is that computing is becoming a basic skill, on the order of reading and writing. Education should teach this skill so that the student himself can access the vast store of information available in an appropriate educational information system, and find his own answers. "It would be a shame if we denied the student the competence to use the computer as an intellectual resource. We are turning out technologically unemployable people in the future if we deny this really elementary kind of skill. Computing is a technique that ought to be shared with the student, as opposed to being used merely to carry out the teaching. It should be the thing taught."

A third unique aspect of the computer, that arises from its enormous information-handling capacity, is the potential to simulate dynamic systems. The student can interact with such a system, receiving immediate feedback on the appropriateness of his inputs, in situations where it would be impossible to have such free play in the real system, because of physical and practical constraints. Examples range from running an experiment in nuclear physics, to flying a jet, to managing an economy according to a given model. In line with this sort of structured interaction or game, in which the student learns *the system* instead of facts *about* the system, the computer has a significant potential for teaching information processing and the associated problem-solving skills. This is, in a sense, a kind of content-neutral or content-independent notion of instruction, which might be advantageously used in teaching students how to make the kinds of decisions they actually have to make when selecting their own learning sequence. Decision-making abilities in terms of processing information effectively are not part of the usual set of skills specifically developed by

traditional instructional methods. The use of CAI for process teaching – i.e., through simulation and gaming – was thus considered a primary contribution that the computer could make to education (see Item 1, Table 2). Simulation and gaming were judged to be forms of CAI that would also elicit a substantial market and thus should be developed much more extensively.***

The fourth point involves the fact that the computer has an almost infinite capacity to take into simultaneous account enormous numbers of facts about a student – his knowledge, ability, preferred learning patterns, etc. The computer can use this information, in what could be a powerfully effective way, to select from vast numbers of alternatives the next instructional goal or testing item most appropriate to the individual student. However, our present understanding of individual differences and our present capacity to identify them and respond with differentiated instructional sequences are many orders of magnitude less than needed to exploit this capacity of the computer. We are not yet in a position to take real advantage of this potential, even though the individualization of sequences is commonly regarded as one of the attributes of CAI that can make it exceptionally effective in instruction. Consequently, there is urgent need for extensive research in a) testing techniques able to make fine discriminations of achievements, potentials, response patterns, learning patterns, etc.; b) the development of theories regarding the underlying relationships among these variables; and c) the development of pedagogical techniques and sequences of materials responsive to the individual patterns.**

Research Use

It may be that the computer itself will provide a basis for the development of learning theories. The computer has unique capabilities for data collection and analysis during instructional use and for virtually instantaneous updating and improvement. More significance should be attached to the fact that CAI can be used in a research mode, uniquely, to gather information about learning.* Through this important capability, we can acquire greater experience with student use of computer material and thus can continually modify it. Only such experience can teach us what computer techniques and material are educationally sound. In this regard, there was strong agreement that CAI both affords and necessitates a research and development effort to study the comparative effect of instructional strategies, and the theoretical and measurement problems involved. This would lead to continued refinement and eventual good achievement rather than overnight success. It would also be useful to do studies of CAI's potential for reducing the cost of developing materials, in addition to increasing their quality.

Learner Control

Learner control was recognized by many to be a very important although little explored dimension of CAI research. Several attitudes underlie this issue:

1) The computer ought to be used more as an intellectual resource controlled by the student.
2) The concept of learner control focuses on teaching the student to judge appropriate strategies for obtaining and using information

– a critical educational function in itself and a uniquely appropriate task for the computer.

3) Learner control represents the most direct approach to individualization, effective to the extent that the student can judge what works best for him.

Several participants, however, expressed doubt about the practicality of relinquishing to students effective control of their learning sequences.* At the most basic level, one respondent pointed out, we need more data to show that learners can control their learning more efficiently than someone else. Data at present do not unequivocally support this position. It was also suggested that learner control will be a very difficult and expensive option to achieve in CAI systems and should therefore be tackled only at a much later stage. A final point was that learner control studies need to be designed with sufficient numbers of options, in order to evaluate the true impact of learner control. That is, studies should provide options for learning which include no use of the computer along with options in subgoals, in content, and in sequencing the materials.

D. Educational System and the Teacher

A broad use of CAI will require a change in the established patterns of instruction and a restructuring of the traditional role of the teacher, particularly at the precollege level. It will also eventually entail more rigorous analysis of cost effectiveness, specification of goals, and measurement of instructional efficacy. These will follow from the inevitable application of CAI to management and research modes as schools grow familiar with the computer's information-processing capabilities, and these applications will serve to provide a basis for systematic improvement of educational methods. A number of problems have been encountered or are anticipated, as indicated in Table 6.

There was agreement among participants that more information and training programs are needed, to counter the lack of knowledge and prejudice of teachers and administrators with regard to the computer. Divergent viewpoints were expressed as to the role of teachers in aiding implementation and creating materials for CAI; some felt that teachers' interest and potential contribution would be high, while others sharply disagreed. Additional issues which received discussion – and which are summarized in the remainder of this section – were evaluation and documentation, computer-managed instruction (CMI) and the need for major revision of education.

School Resistance

A number of reasons were suggested for the apparent resistance to CAI of the precollege educational system. They included:

1) the high cost of computer systems, and the related problems of measuring their cost-effectiveness and justifying the expenditures to the public;

2) the fear of change, especially when it results from a technology as complex as the computer. There is also the expectation that the computer will be another in a series of much-touted technological

TABLE 6

Educational system and the teacher. Responses in this category related to problems underlying the need to change established patterns of instruction and to restructure the role of the teacher.

		unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1.	Reluctance of school personnel to go through reorganization and training that a broad use of CAI would entail.			M		
2.	Cautiousness and uncertainty on part of educators as to effectiveness of CAI in comparison with traditional teaching methods.			M		
3.	Scarcity of resources available to train teachers and others in the skills required to use CAI successfully.			M		
4.	Fear of educators of being reduced to a "button-pushing" or clerical role by computer.			M		
5.	Reservations as to possible negative effects of removing instructional process from social situation and replacing interpersonal feedback with mechanical.			M		
6.	Extreme diversity of, and lack of coordination among, school systems throughout the country.			M		
7.	A prevailing attitude that the computer will be used to replace poor teachers instead of to make good teachers more effective.		M			
8.	Insufficiency of evaluative techniques, criteria, and agencies with which to satisfy educational standards.		M			
9.	Not enough opportunity for local school people to participate in development of CAI programs.		M			

tools that have for various reasons failed to live up to initial promises (radio, TV, language labs, programmed instruction devices, etc.);

3) the ignorance of the computer's potential, limitations, and adaptability – factors to be resolved only by teacher training; and,
4) the clash of values, arising from the teacher's feeling that the computer will deprive him of highly valued personal relationships with students.

One participant suggested that presenting fully developed programs, that utilize the teacher only in a minimal way, has contributed to the teacher's doubt and antagonism.

These problems are probably more severe at the lower academic levels, where computers may be used to augment or replace a relatively large portion of a teacher's total activity. At the university level the instructor will suffer little threat to his professional self-esteem; he can become involved in developing programs himself, and thus is a potential advocate, not a resister. There will also be clear rewards to the community college teacher, since the computer does not threaten his role; rather, it offers hope of dealing with problems the faculty would prefer to escape.

Further aggravating teacher resistance is the present oversupply of trained teachers. For CAI to be cost-effective at this time it probably will have to produce some reduction in teaching staffs, in favor of greater use of paraprofessionals. That reduction might be slight, and perhaps could be satisfied by the attrition that normally takes place in schools. But any

substantial staff reductions needed in the interests of cost effectiveness would be difficult or impossible to obtain at present, particularly now that so many teachers are unionized.

One conferee asserted that the issue of staff reduction has resulted in unfortunate kinds of pressures on school boards, the crucial element in school systems. "The public is told that CAI can reduce costs; at the same time it is told that, because you have to think about the teachers' union, CAI will *not* replace teachers. Now, everyone knows that if you are not replacing teachers, you are not only not reducing costs, you are adding to costs. Because there hasn't really been an honest dialogue on this, the people who eventually have to make the decision whether there should be money spent on CAI – the school boards – are not very receptive."

Teacher Involvement

There was a wide divergence of opinion among participants with regard to the importance of teacher involvement in introducing CAI to educational systems. A few comments were very negative in assessing the competence or interest of teachers in implementing educational improvement. For instance, "If released to meddle more profoundly in the student's intellectual development, they would probably do more harm than good."

The more prevalent view was that teachers, particularly at the pre-college level, are locked into traditional teaching styles by lack of training, free time, or rewards, and that they would, if freed from these constraints, be open to and actively interested in innovations that were demonstrable improvements over traditional techniques, and would have much to contribute. It was remarked that a teacher who has been exposed to and convinced of CAI's value makes its most effective proponent. The conferees described several instances of teachers becoming enthusiastic about CAI, independently of any sales pitch or external pressure, simply because it visibly met a concrete need. For example, ". . . Some years ago I had a fellow come and explain how he was using a table of random numbers to generate all the forms of a test to a group of teachers of low achievers. . . . These teachers are very receptive because we've tried a lot of things that we know are not working. And so he said, 'Well, really, if I wanted to generate more than five test items I could do it on a computer.' And the teachers right away said, 'That's great!' Now, this was a realistic possibility, to get one terminal in the building. So they started looking, and as a matter of fact we did get a manufacturer to develop the thing and let us use it free for a couple of years. This is where we got started. . . . I'd say by this year probably half our secondary students will have written and run a couple of BASIC programs. The teachers are very receptive, very positive to this because it's coming in as something that helps them; it's something they have a vested interest in. . . ."

Another example was offered by a university professor: "If teachers *see* materials, if you can somehow force them to look at materials, if they turn out to be extremely relevant to their needs, they see it very quickly. We had an experience a couple of weeks ago with a colleague of mine. . . . He came in asking what sort of equipment we had around for demonstrating

motion, and we told him about a simulation that lets you look at almost any aspect of motion on a graphic terminal. He was very negative; he said no, no, he didn't want any damn computers and he didn't want the students to program – the typical kind of response. Well, in the course of showing him other things, we sort of dragged him up to the terminal. Ten minutes later the story was exactly the opposite; now our problem is that we only own two of these graphic terminals. And it's simply because there was something that fitted in with his needs in the course, and he saw this even though he was very negative."

Teacher Training

The education of teachers in CAI techniques is a prerequisite to full acceptance of computer use in education.** Very little progress is likely to be made until teacher-training institutions enter CAI in depth. Their efforts would have to include practical training in the use of the hardware, the understanding of the software, and the techniques of integrating CAI with the traditional educational process. Without this background training, CAI applications will not be wholly successful – the new techniques will only be used to replicate traditional classroom practice.

In addition to providing useful techniques, proper training would effectively counter the misunderstandings as to the purposes and limitations of CAI which have led to prejudices and biases against it. Many teachers are confused about its potential and object to its use as dehumanized or mechanical. Others are apprehensive that the computer will replace them or reduce the importance of their role. When these concerns are combined with the prejudice in favor of the print media, the result is a significant force for maintaining the status quo. However, if more of the professional training of teachers is directed toward the understanding of CAI, current biases will tend to dissipate.

Teacher Control

One way to ensure that teachers are comfortable with CAI systems is to design systems that are aids to, or are controlled by, the teachers. Not everyone agreed, however, that this was a good way to gain teacher acceptance; the concept of "control" was especially attacked in this context.

"I think if you talk about teacher control, you're reinforcing one of the worst kinds of stereotypes, and that's the one thing we've got to destroy: that there's somebody who teaches people and that the teacher controls the situation, the teacher's in charge. We should try to get that teacher to change that role – not to be up in front of the room, but rather to be assisting, tutoring if you like, but getting out of that role of being in control of that classroom." In short, the opposing view held that it is precisely the teacher's traditional control that education should be getting away from. The suggestion was that there should be a change in educational philosophy which would result in the teacher's role being one of guidance and assistance, rather than control.

Local vs. Professional Development

Curriculum development by local teachers rather than by professionals was judged to be an issue of moderate importance. While some participants

felt that major program development could be centered in the schools, the majority doubted that this was practical. One school administrator did point to several successful programs that teachers in his system had independently created to meet certain needs. Most participants, however, felt that the main effort of development must be undertaken as a full-time professional job, and that good CAI materials are so expensive to prepare that producing them will have to be done under centralized auspices. They added, however, that teachers should be provided an opportunity to contribute to and modify program material, possibly to the extent that leaves of absence should be arranged for selected teachers to permit their participation in program development outside their schools. If teachers are to prepare effective programs, they must, of course, develop the special competencies required to design, write, test, and revise instructional packages.

The extent of interest in local versus professional development will vary as a function of educational level. At the higher educational level, one should expect intense interest in local determination of course content; no professor at a major university is likely to consider himself less competent to design curricula than any of his colleagues, nor will he ever agree entirely with a curriculum prepared by somebody else. At the secondary and elementary levels, however, less intense personal concern may be expected, since these teachers are typically more willing to use without modification curricula prepared by others.

Course Objectives

The lack of clear-cut course objectives was considered to be a notable obstacle to developing truly effective CAI programs and to comparing CAI with conventional teaching methods.** This absence of objectives was also seen as a general educational problem. One participant pointed out that most students and many teachers are likely to be confused about the objectives of a given course and, about what the end product is supposed to be. One of the most valuable side effects of the CAI approach is that it forces educators to pay attention to careful definition of course objectives. Thus, CAI benefits instruction by explicitly exposing ignorance of the learning process. It forces decisions about teaching programs that are usually not made because the need for them is not apparent.

CMI

Some mention was made of the value of computer-managed instruction particularly in reducing costs and gaining acceptance for the computer through demonstrating its practical utility.* One conferee offered the opinion that CAI will come into being in schools when capital costs are covered through introducing computer information systems for management purposes. Another view was that management use of the computer would be an intrinsic part of moving toward a more technology-based educational system.

Educational Revision

A few respondents were pessimistic about the adoption of CAI without major redesign of present school systems to accommodate it: "I believe

that CAI will not have broad educational application in elementary and high schools for a very long time, if ever. CAI represents a major commitment to a new technology and a new threat to the status quo. School systems do not have the necessary organizational behavior and management skill to handle such a threat. As they are now organized, staffed, and financed, there is no payoff for change. . . ."

It was suggested that the effort to advance CAI should be one part of a large-scale effort to update the educational system, with careful coordination of development and adequate funding: "The successful use of computers in education is dependent upon a major substantive revision of the conventional educational process." Such a revision is a systems design problem, is extremely costly, and is beyond the financial capability of any single educational entity. The design, test, and evaluation of an effective, practical, and economically viable educational system would best be financed by the federal government and approached with the same commitment as (a favorite analogy) the project for landing a man on the moon. Such a program will automatically require the use and acceptance of the computer and associated systems in education.

Evaluation and Documentation

There was agreement that evaluation of CAI systems is important to the ultimate acceptance of computers in the educational process.* There need to be detailed evaluation studies providing school administrators with the justification for introducing new capital-intensive equipment and techniques. Evaluation must show time effectiveness, and cost effectiveness comparable or superior to present results. It is critical to show that the computer can overcome some difficult instructional problems that currently exist. If CAI developers can present school superintendents or school boards with evidence from an independent auditor indicating significantly better achievement with CAI than with other methods, the ultimate acceptance of CAI will be greatly facilitated. In this regard, several participants emphasized that the present reluctance to invest in CAI is not due to fear or lack of interest, but to not having sufficient evidence that CAI represents educational improvement. There have not, they alleged, been many persuasive reports of CAI's value in education. In addition to careful evaluation, there should be intelligent, honest, critical reviews of the results of demonstrations, well written, interesting, and widely disseminated.

The documentation and validation of current instructional programs is also an important need. This area shares with evaluation the problem of devising appropriate standards against which instructional success can be measured and of creating effective organizational structures. Documentation as well as evaluation will require some degree of formal organization and financing. No agency has been established to do the job, and personnel who could carry it out effectively are scarce.

One participant held the view that once a market is established, evaluation will take care of itself. That is, the better materials will naturally be those which are most popular and in greatest demand. However, the more widely held attitude was that the educational market is not, nor should it have to be, sophisticated enough to effectively judge the worth of CAI

systems, in which public funds must be invested. An extensive and carefully planned experimental design is required to prove actual benefits in relation to cost; hence evaluation must be systematic and professional.

In connection with evaluation, a participant noted that one must also consider alternative, and less expensive, means of presenting the same material and activities. Clearly much of the drill and practice can be accomplished in other ways: perhaps a teletype (or talking typewriter) could be replaced by a programmed text and a guide for a paraprofessional working with the student at an electric typewriter; much of the expository materials could be presented by slides or programmed texts, etc. It is important to look at these options because a primary concern of the evaluators will be to consider less expensive ways to achieve the same end.

E. Cost

This category grouped together problems related to the cost effectiveness of computer-based instruction. Two central issues were identified. First, CAI is an add-on cost that does not reduce the instructional budget – in fact, it increases the personnel budget by the addition of required programming support. Second, even where good cost effectiveness can be achieved over the long run, the high initial capital investment makes implementing CAI prohibitive. Table 7 shows the specific items and responses relating to problems of cost that were judged to be important.

TABLE 7

Cost. Responses in this category dealt with problems of cost-effectiveness of computer-based instruction.

		unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1.	Fact that CAI is an add-on cost, not reducing instructional budget, and requiring additional programming personnel.					M
2.	High capital investment even where good cost-effectiveness can be achieved in the long run.					M
3.	Poor cost-effectiveness, to date, of computer-based instruction.				M	

Nature of Cost Problems

In general, the problem of cost was considered to be an important obstacle to computer acceptance, but not necessarily one to which great effort should be directed at this time.*** As one respondent wrote, "In spite of the fact that sheer cost of computing has most limited the widespread use of computers in instruction, I do not recommend more emphasis on this area than already exists. Education is not likely to force computing costs downward any more rapidly than other markets for computers are now forcing costs downward. Therefore, education would be better advised to concentrate on unique needs in computing hardware and software and simply to wait out the cost problem." Other respondents felt that by the time materials are organized for a computer-assisted

medium of instruction, and schools properly funded and administered in a way permitting CAI to be tried, the cost problem will have been solved by agencies outside of the schools.* Industry, business, and government bureaus have already installed large networks of remote terminals for their own purposes, and their coming into use for instructional ends is only a matter of time. To the business or industrial user, the high effectiveness of instructional technology can be translated into terms that are easy to evaluate, namely, economic terms. Thus it is these users' requirements that will probably accomplish more than any additional efforts to bring down costs on behalf of educational institutions. In short, the majority opinion was that educators should not at this stage be especially concerned with cost. By the time CAI is truly ready for widespread use in instruction, the cost factors may be entirely altered.

Cost Effectiveness

A substantial problem in solving the issue of cost is the difficulty of measuring cost effectiveness in educational systems, where goals are usually inadequately defined.** Schools traditionally have not seen it as their responsibility to examine and specify instructional objectives. Where objectives do exist, as for example in the military and some areas of industry, CAI seems to be very cost effective and the use of programmed instruction, by means of computers and other media, has grown steadily.

As an example of the problems to be encountered in cost effectiveness measurement, one participant pointed out that "The largest cost factor in instruction is the teacher's salary, but the time that many current CAI systems would 'save' would be the 10 hours, approximately, the teacher contributes after school (lesson plans, test preparation, grading, etc.), time which represents a 'free' resource traditionally contributed by the teacher to the school. Thus, the notion of effectiveness implied in the concept of 'cost effectiveness' is foreign to current school operation."

Several participants noted that one of the most beneficial effects of CAI is that it will require a clearer specification of educational objectives. All schools, at least implicitly, do have objectives and, in every budget, do make cost effectiveness judgments about their attainment. But they do not define the objectives clearly nor quantify them adequately. The result is that the judgments as to cost effectiveness are usually ill-formed or unreliable. Consequently, schools do not have sufficient incentive to increase effectiveness, because there is no systematic feedback indicating the school's performance in achieving instructional goals.

Inappropriate Accounting Methods

In the view of several respondents, elementary and secondary school staffs tend to be prejudiced against CAI, because they feel that the high cost per student hour of CAI cannot justify its replacing traditional teaching methods. Clearly, since cost effectiveness is a significant issue in the acceptance of computers in instruction, there will have to be careful analysis of existing costs, at all levels and for different subject matter, in order to establish a baseline for comparison. However, there are obstacles to such a comparison. The current budgeting practices of public school sys-

tems do not take account of the increased speed at which CAI-taught students may reach course objectives, nor do they recognize that CAI may not simply replace traditional techniques; instead, it may provide a higher quality of educational product than achieved in conventional instruction. These problems in comparing instructional methods are exacerbated by the inability of most schools and colleges to measure the cost or effectiveness of conventional instruction. As one participant noted, "There is a general failure to understand the systems nature of the educational problem and therefore a failure to understand the true costs – direct, indirect, and social – of education or lack thereof."

Cost Factors – College and Precollege

If cost problems are to be attacked by the educational community, they will, for a number of reasons, be more readily resolved at the college level.** First of all, the ability to pay obviously differs widely with level in terms of the observed expenditures, per student hour, for education. There are fewer restrictions on institutions of higher education in allocating funds and reordering budget priorities than there are in elementary and secondary schools. The elementary school budget cycle is geared to meeting annual operating costs that cover, for the most part, teachers' salaries, plant operations, debt retirement, etc. Any heavy capital investment, requiring amortization over a prolonged period, is hard to finance under current funding practices. Also, it is difficult to reschedule school expenditures to take account of capital and operating costs when savings cannot be directly counted. Finally, computer resources, in terms of hardware, personnel, and access to shared time in underutilized central computers, are much more likely to be present at universities.

F. Technical Research and Development

This category comprises problems relating to the technological side of CAI development. It was generally agreed that not enough has been done in CAI design in terms of perfecting appropriate hardware, and that more effort needs to be put into creating effective, specialized, flexible equipment. One point of dispute was the importance of natural language processing as a critical technical capacity that must eventually be developed in CAI; different concepts of CAI's ultimate role were reflected in this disagreement.

Table 8 lists specific factors in this category that were rated in the questionnaire sequence.

Hardware Systems

Several issues in the area of research were identified as moderately important to CAI acceptance. One research issue is the need for improvement in the available CAI hardware systems.** One major criticism, which underlies Items 1, 2, 4, and 5 in Table 8, is that current hardware is not appropriate to educational use. At the level of the man/machine interface, there is need for education oriented terminals. Present computer terminals are designed for business, not education. They are often noisy and unpleasant to use, and in many cases they do not supply the response options

TABLE 8

Technical research and development. Obstacles in this category related primarily to the technical problems of providing adequate delivery systems for CAI.

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Unreliability of hardware, in terms of frequent breakdowns due to heavy use by students and insufficient servicing.			M		
2. Dissatisfaction with design of presently available terminals.			M		
3. Limitations in the kinds of student inputs interpretable by the computer.			M		
4. Lack of readily available and appropriate hardware systems.			M		
5. Use of systems in which fixed information is funneled through computer's core storage and central processor instead of being maintained in highly accessible low-cost media such as magnetic tape, audio tape, video tape, etc.		M			
6. Lack of a simple author language which would enable teachers to prepare effective programs without extensive training.		M			

that are critical to selection of instructional sequences.

Terminal design was the most frequently cited problem of current hardware systems. Particular terminal capabilities identified as being important for education were these:

1) a high volume random-access audio unit for use in teaching reading and languages;
2) a video-cassette attachment for use in presenting fixed information under computer control; and
3) a display capability that includes the use of light pen and the ability to produce hard-copy output.

The consensus was that in the area of technology, terminal engineering is far behind central-processor engineering. Intensive development could produce terminals that are inexpensive, reliable, and fast; it should also provide the capabilities described above.

Another problem rises from the experimental nature of most current CAI programs. Much CAI experimentation has been conducted on large-scale computers developed for general-purpose time-sharing in business, industry, and science. These large-scale configurations impose programming-systems constraints that are subject to many levels of complexity and frequently lead to problems of unreliability. It is unlikely that mass dissemination can come about with these systems. Therefore, further development of systems must be engineered that provide the computer logic and architecture appropriate to the primarily nonnumeric processing demands of CAI.

Natural Language Processor

One issue, on which there was substantial division of opinion, was the need for natural language processing capability and greater in-depth exploration of artificial intelligence techniques (Item 3, Table 8). One group felt strongly that the ultimate success and acceptance of computers in the instructional process would depend to a large extent on the computer's capability for natural language processing. It was their contention that the limitations on student input imposed by the inability of the computer to accept free-form responses (or questions) were a critical impediment to widespread computer use. The point of view of the advocates of natural language processing was well represented by one participant, who noted that "for complete mastery of a concept, the student should be able to explain the concept in his own words, compare it with related concepts, correct a mistake in judgment about the concept, and so forth. These are the kinds of responses we use to judge whether or not someone understands a concept. And CAI systems will have to be able to accept and interpret such inputs, if CAI is eventually to play a significant role in education." On the other hand, those who did not favor continued research in the area of natural language processing pointed to the success of programmed instruction and contended that CAI can realistically teach any subject or concept when programs are developed with ingenuity. It was their contention that it is a waste to try to remake the computer to do something for which it is ill-adapted or totally unadapted, when there exist so many things that the computer can do superlatively well. An analogy would be to criticize a book's inability to reproduce sound as making it ill-adapted to teach music or speech, and recommending development of an audio function for books, ignoring the fact that there are already tapes and records at hand that carry out that function.

Programming Languages

The suggested need for new and more appropriate CAI programming languages was considered relatively unimportant (Item 6, Table 8). A number of respondents commented that many such languages now exist, but do not seem to be of particular use. For the most part, CAI programming languages are trivial and do not treat the full range of problems encountered in preparation and debugging. Consequently, general-purpose languages, for facilities designed for particular tasks, are more often appropriate and useful. Many respondents felt that the proper production of CAI materials would best be accomplished by an author working solely on analysis and representation and supported by a technical team to carry out the programming. Hence, there would be no need for a simple author language.

Chapter V

Conclusions and Recommendations

The problems of CAI acceptance and use are numerous and complex. As noted earlier, they have three major dimensions – educational, economic, and technical – that are reflected in the six categories of problems discussed above. The educational dimension, relating to the availability of adequate materials and the lack of evidence of CAI effectiveness, was judged to be the most critical. The second most critical dimension is economic. However, while recognizing that economic factors are significant and pervasive, the study group felt that the problem of high costs would be alleviated by ordinary market pressures to bring computing costs down. Finally, the technical dimension, which is mainly concerned with creating adequate CAI delivery systems, was judged not to be of critical importance in comparison with the sizable economic and educational problems.

In approaching the overall problem of CAI acceptance and use, it is helpful to recognize the existing circularity of the analyses. For example, the major educational question "How can evidence of effectiveness be provided?" evokes the following sequence of answers: To provide evidence of effectiveness, one must (a) conduct a convincing high-quality demonstration. But (b) to conduct a proper demonstration, one needs good computer-based materials. But (c) to develop good materials, one needs good people who know theories and methods of instruction and are sensitive to the role of the teacher and problems of the classroom. But (d) to get good people, one needs professional recognition and economic incentives. But (e) to get professional recognition, one needs evidence of the value of the pursuit (see point a) and to get proper economic incentives one needs a formal production-distribution system (as in textbook publishing) and an active market. But (f) to establish a production-distribution system and market, one needs a demonstration of effectiveness to convince potential investors and buyers of CAI's value – and we are back at the beginning.

This circularity suggests that, theoretically, an infusion of funds at any one of these steps might advance overall development by reversing the cycle. It also indicates that a large-scale program of funding would have to take these interdependencies into account. For example, drawing on recommendations outlined in Tables 9 and 10 and the original action plans

TABLE 9

Action statements suggested by the conference attendees to be promising means for enhancing a more widespread use of computers in instruction.

1. *Simulation and gaming.* Concentrate curriculum development efforts on utilization of the computer's unique capabilities, e.g., in problem-solving exercises, simulation, and gaming.

2. *Learner control/learning styles.* Develop systems that allow more learner control of the material and of the style of teaching.

3. *Educational terminal (graphics/audio).* Organize a team of industrial designers, engineers, teachers, and students to develop one or several educationally oriented computer terminals.

4. *Learning theories.* Develop a foundation of theories of learning and experimental data which would enable the computer to be maximally flexible and effective in teaching, as opposed to being a page-turning and response-recording device.

5. *Support teachers in CAI development.* Identify teachers who are good writers and who have classroom experience in computer applications and support them in the writing, publishing, and distribution of quality curricular materials.

6. *Summer workshops.* Institute summer workshops to provide teachers with hands-on experience with available CAI systems.

7. *Software format.* Establish a format for the production of software that will make it usable in a variety of hardware systems.

8. *Cooperative/competitive.* Develop programs in which the student questions the computer rather than the reverse (cooperative rather than competitive use of the computer in a learning situation).

9. *Model town.* Set up a large-scale model demonstration of CAI-in-the-home in a new town (200 new towns are now in some stage of planning or construction in the U.S.).

10. *Model schools.* Set up one or more CAI-based model schools (elementary schools, high schools, or college campuses).

11. *Cooperative project.* Implement a cooperative project involving a community college system and a major commercial producer of educational materials to develop, test, and demonstrate a remedial course, such as remedial English.

12. *Large-scale demo.* Mount a large-scale experiment to demonstrate the economic feasibility of CAI.

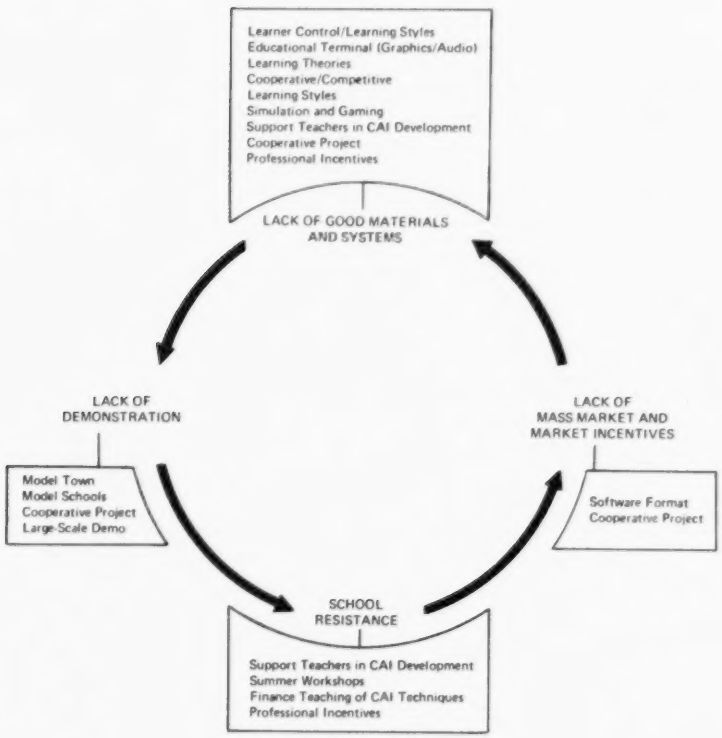
13. *Finance teaching of CAI techniques.* Finance teacher training institutions to include practical training in the use of hardware and software, and in the techniques of integrating CAI with the traditional education process.

14. *Learning styles.* Develop the capability to identify and match student learning styles in different content areas with appropriate pedagogical techniques.

15. *Professional incentives.* Establish professional incentives for university faculty through a grant program that requires from the recipient university assurance that work on CAI development would be judged equivalent to research, in terms of promotion, salary, etc.

TABLE 10

The fifteen recommended action plans as suggested directions for breaking the status quo cycle.



in Appendix 4, one might design a multi-level program of complementary research-and-action projects directed toward the teaching of remedial English. At the action level, the components of the program could include (1) a cooperative project to develop, test, and demonstrate course materials, and (2) within the context of the cooperative project, a provision to train and support teachers in the writing of course materials. The cooperative project could involve a community college system and a major commercial producer of educational materials, with professional collaboration of retained outside experts. The project would design the course, prepare the program and materials, including related conventional print and audio-visual materials, and test and refine them through two academic years. Concurrently, a laboratory could be established to train authors and supporting technical teams and to prepare faculty to use hardware and software in techniques of integrating CAI with traditional course materials.

Research, suggested by Tables 9 and 10, that could feed into and refine the development of the course, and also capitalize on the availability of experimental resources, could include (1) a study to identify and match student learning styles with appropriate pedagogical techniques, and (2) a project to develop a more appropriate educational terminal. The study of learning styles would test the relative effectiveness of different pedagogical techniques (drill-and-practice, tutorial, problem-solving, etc.) in relation to the structure and complexity of the material being taught. At the same time, research could be undertaken to identify computer terminal features (e.g., random-access audio capability for teaching reading and language skills, computer-controlled video capability, etc.) that might be particularly appropriate for educational applications.

These examples are noted to show how a multi-level program of research and implementation might be directed toward overcoming the most critical obstacles to CAI acceptance, thereby gaining enough momentum to reverse the 'status quo cycle.' Many other examples could be drawn based on the obstacles and probable resolutions identified by the project participants. The data base of opinion contained in this study should prove useful to CAI developers and funding agencies in setting research and funding policies likely to promote greater and more effective use of computers in instruction.

Appendix 1

The Questionnaires

Following are copies of the three questionnaires used in the first phase of the study.

EDUCOM

INTERUNIVERSITY COMMUNICATIONS COUNCIL, INC.

Post Office Box 364 · Rosedale Road, Princeton, New Jersey 08540 · Telephone 609-921-7575

QUESTIONNAIRE 1

Study of Factors that have Inhibited a More Widespread
Use of Computers in the Instructional Process

The potential of the computer in science and education has been widely recognized and is attested to by the growth of applications in these fields during the past two decades. In certain areas, i.e., data analysis and research, considerable gains have been realized and many spectacular successes recorded. However, the computer is far from being accepted in one major area in education: use of the computer in the instructional process itself. There have been a number of successful experimental demonstrations of its potential value, but the computer has yet to begin to be integrated within present instructional systems.

The purpose of the project in which you are participating is to identify those factors which have inhibited the widespread use of computers in the instructional process, and to suggest possible means for resolving these difficulties.

Questionnaire 1, attached, is the first of the sequence of three questionnaires which will be utilized in the study. It consists of four questions. The first, in two parts, is posed in order to derive a working frame of reference as to what the desirable outcomes and potential contributions are, or might be, from the introduction of computers into the instructional process. The second and third questions are the first step in the exploration of the difficulties encountered or anticipated in the realization of those outcomes. The last question will serve to indicate the extent and nature of each respondent's experience in computer-assisted instruction.

It should be noted that, throughout the questionnaires, the term computer-assisted instruction (CAI) will be used as a generic term. It will not be limited to computer-programmed instruction but will be used to denote all aspects of the utilization of the computer in an instructional context. Included within the scope of the term as used in this study will be what some have preferred to call computer-augmented instruction, computer-managed instruction, computer-based education, and also problem-solving, gaming, simulation, etc.

Question I

IN WHAT WAYS DO YOU BELIEVE THAT THE USE OF COMPUTERS IN INSTRUCTION WOULD IMPROVE THE EDUCATIONAL PROCESS?

(A) First estimate the desirability of each item as an educational improvement, using the checklist and the following scale:

1 = not desirable
2 = slightly desirable
3 = moderately desirable
4 = very desirable
5 = extremely desirable

If you rate an item as '1' (not desirable) please make a note of the considerations on which you have based your rating, on the reverse side of this sheet.

	1	2	3	4	5
1. Would enable student to proceed at own rate, without pressure of "lockstepping".					
2. Would provide instant feedback, with the result of more efficient learning.					
3. Would make possible immediately available records on student's learning history.					
4. Would enable student to select his own learning sequence.					
5. Would provide more controlled learning environment; student not as subject to the negative influence of poor teaching.					
6. Would facilitate flexibility of learning program with regard to time and place; e.g., courses could be made available in public libraries for working adults, or in homes.					
7. Would free the teacher from the more routine, "drill-and-practice" aspects of teaching.					
8. Would free student to concentrate on material to be learned without pressure of competition from peers.					
9. Would help to insure bias-free educational environments for minority groups.					
10. Would encourage a more freely questioning attitude by removing fear of making errors or asking inappropriate questions.					
11. Would shift the emphasis in student evaluation toward attainment of objective learning criteria and away from placement in a normative "curve".					

Question I (cont'd)

IN WHAT WAYS DO YOU BELIEVE THAT THE USE OF COMPUTERS IN INSTRUCTION WOULD IMPROVE THE EDUCATIONAL PROCESS?

(B) As a second step, rate each item as to the computer's potential contribution in effecting the improvement, using the following categories:

1 = would contribute nothing
2 = would contribute little
3 = would contribute moderately
4 = would contribute substantially
5 = would contribute in a critically or extremely important way

If you rate an item as '1' (would contribute nothing), please make a note of the considerations on which you have based your rating, on the reverse side of this sheet.

	1	2	3	4	5
1. Would enable student to proceed at own rate, without pressure of "lockstepping".					
2. Would provide instant feedback, with the result of more efficient learning.					
3. Would make possible immediately available records on student's learning history.					
4. Would enable student to select his own learning sequence.					
5. Would provide more controlled learning environment; student not as subject to the negative influence of poor teaching.					
6. Would facilitate flexibility of learning program with regard to time and place; e.g., courses could be made available in public libraries for working adults, or in homes.					
7. Would free the teacher from the more routine, "drill-and-practice" aspects of teaching.					
8. Would free student to concentrate on material to be learned without pressure of competition from peers.					
9. Would help to insure bias-free educational environments for minority groups.					
10. Would encourage a more freely questioning attitude by removing fear of making errors or asking inappropriate questions.					
11. Would shift the emphasis in student evaluation toward attainment of objective learning criteria and away from placement in a normative "curve".					

Question I (cont'd)

IN WHAT WAYS DO YOU BELIEVE THAT THE USE OF COMPUTERS IN INSTRUCTION WOULD IMPROVE THE EDUCATIONAL PROCESS?

Please add any additional items, or restatements of items which you feel are unclear, in the space below, and rate them in terms of their desirability and the computer's potential contribution. Use additional sheets if you wish.

	A Desirability					B Computer's Role				
	not desirable	slightly	moderately	very	extremely	no contribution	little	moderate	substantial	extreme
	1	2	3	4	5	1	2	3	4	5
12.										
13.										
14.										

Question II

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Below are listed a number of suggested reasons. Please rate each in terms of importance, using the checklist and the following scale:

1 = unimportant factor
2 = slightly important factor
3 = moderately important factor
4 = very important factor
5 = extremely or critically important factor

If you rate an item as '1' (unimportant factor), please make a note of the considerations on which you have based your rating, on the reverse side of this sheet.

Please add to the end of the list any further possibilities, or restatements of items which you feel are unclear or inaccurate.

	1	2	3	4	5
1. Poor cost-effectiveness, to date, of computer-based instruction.					
2. High capital investment even where good cost-effectiveness could be achieved in the long run.					
3. Lack of readily available computer-based educational materials.					
4. Lack of carefully planned broad programs of CAI experimentation in actual school settings.					
5. Extreme diversity of, and lack of coordination among, school systems throughout the country.					
6. Reservations as to possible negative effects of removing instructional process from social situation and replacing interpersonal feedback with mechanical.					
7. Insufficiency of evaluative techniques, criteria, and agencies with which to satisfy educational standards.					
8. Uncertainty as to who should distribute software and provide training and services for its users.					
9. Not enough opportunity for local school people to participate in development of CAI programs.					
10. Fear of educators of being reduced to a "button-pushing" or clerical role by computer.					

Question II (cont'd)

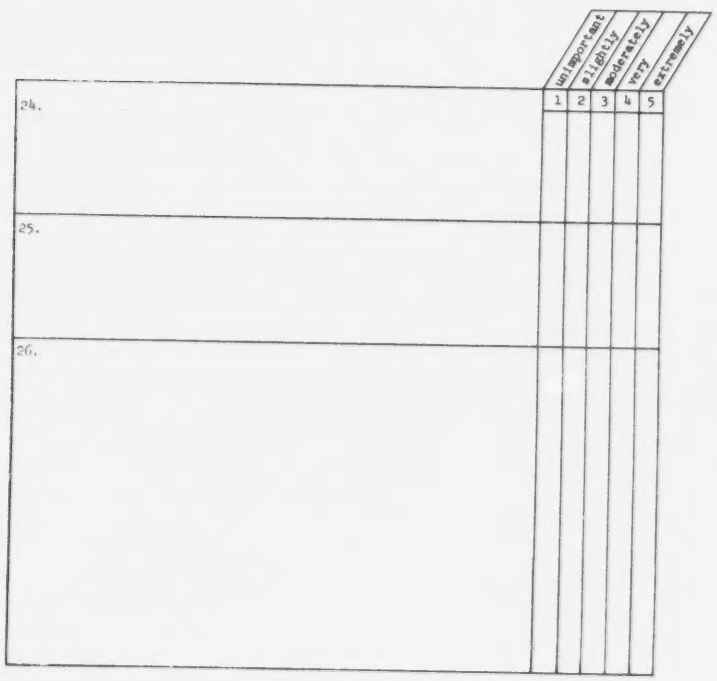
WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
11. Cautiousness and uncertainty on part of educators as to effectiveness of CAI in comparison with traditional teaching methods.					
12. Lack of experimental data and theories in learning psychology which would facilitate the design of effective CAI programs appropriate to each age level.					
13. Limitations in the kind of student inputs interpretable by the computer.					
14. Lack of professional and economic incentives for development of computer-based materials.					
15. Lack of incentives for dissemination of software.					
16. Lack of standardization of computer systems, limiting free exchange of software.					
17. Reluctance of school personnel to go through reorganization and training that a broad use of CAI would entail.					
18. Lack of a simple author language which would enable teachers to prepare effective programs without extensive training.					
19. Lack of appropriate mechanisms for protecting patents, copyrights, etc. for CAI materials.					
20. Lack of an organization to facilitate interchange of CAI program materials.					
21. Lack of readily available hardware systems.					
22. Unreliability of hardware, in terms of frequent breakdowns due to heavy use by students and insufficient servicing.					
23. Dissatisfaction with design of presently available terminals.					

Question II (cont'd)

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please add any additional items, or restatements of items which you feel are unclear or inaccurate, in the space below, and rate them as you did the preceding items. Use additional sheets if you wish.



Question III

WHAT NEEDS TO BE DONE TO TAP MORE FULLY THE POTENTIAL CONTRIBUTION OF THE COMPUTER TO THE INSTRUCTIONAL PROCESS?

List three or more areas in which additional effort would greatly facilitate the growth, in value and acceptance, of CAI in the future. Indicate, if possible, a time projection for the implementation of each suggestion. E.g., given an appropriate level of effort, would you expect implementation in the 1970's, 1980's, 1990's, 2000's or later?

Listed on page 10 are three sample responses which illustrate the amount of detail requested.

Use additional sheets if you wish.

1.
2.

Question III (cont'd)

WHAT NEEDS TO BE DONE TO TAP MORE FULLY THE POTENTIAL CONTRIBUTION OF THE COMPUTER TO THE INSTRUCTIONAL PROCESS?

3.

SAMPLE RESPONSES FOR QUESTION III

A. The incentives for writing textbooks are obvious and well-defined, in terms of financial rewards, prestige, and enhancement of career. The incentives for writing CAI materials are not so clear; it would be a helpful step for government or private agencies to make financial incentives available, at least initially, for potential writers of CAI programs. In line with this, provisions would have to be made for the safeguarding of copyrights.

B. Courses in individually prescribed instruction and small-group tutoring should be provided in every school of education. Both courses involve skills that will be highly appropriate to teaching in a computer-based curriculum, while at the same time they would be of value in teaching in a conventional school situation. Consequently, schools would not feel they were making an irrevocable investment in CAI, while educators would nevertheless find it much easier to adapt to computer-based systems as a result of having a more appropriate background.

C. Most estimates of the cost of student usage of present CAI systems involve figures many times greater than the corresponding cost per student in conventional schools. Computer-based materials should be able to compete economically with other learning media, i.e., books, blackboards, etc. To combat this problem there ought to be an extensive and coordinated effort to bring down the cost of CAI equipment by applied research. Possibly, in order to encourage the initial capital investments, there should be a subsidization of the installation of CAI equipment in schools.

Question IV

Briefly outline the areas in which you have experience in or knowledge of the use of computers in the instructional process, or experience in the introduction of technological innovations to school environments in general.

Question IV (cont'd)

In addition, please check each of the following categories in which you have had experience.

1. Administration of CAI lab ____
2. Administration of computer center ____
3. Designing of software ____
4. Software development ____
5. Designing of hardware ____
6. Hardware development ____
7. Recordkeeping function of computer ____
8. Design of computer-based curriculum ____
9. Structuring of curriculum content ____
10. Evaluating computer-based curricula ____
11. Training educators in use of computer-based materials ____
12. Teaching with computer-based materials ____

_____ Signature

_____ Date

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QUESTIONNAIRE 2

Study of Factors that have Inhibited a More Widespread Use of Computers in the Instructional Process

Thirty questionnaires were completed and returned in the first round of the Delphi sequence being used in this study. We have tabulated, consolidated and edited the responses, and the data are presented for your consideration within this questionnaire, which represents the second round of the sequence.

Because of the number and length of the responses given in the thirty questionnaires, we have by necessity taken a fairly free hand in editing and deleting. It is hoped, however, that any gross error or insensitivity on our part will be pointed out in your responses.

This second questionnaire consists of three parts. The first part, Question I, was originally presented in order to derive a working frame of reference as to what the desirable outcomes and potential contributions are, or might be, from the introduction of computers into the instructional process. The eleven outcomes suggested were all given fairly high ratings, in terms of both desirability and importance of the computer's role in effecting the outcome. As this seems a sufficient consensus for our purpose, we have simply tabulated the responses and are asking for comments only where you disagree with the consensus, and for ratings on the three new items which were abstracted from the suggestions of a number of respondents.

The second and third parts, Questions II and III, are closely related in that Question II asks 'what are the obstacles to the use of CAI' while Question III asks 'what needs to be done about them'. In this round we would like to begin to bring together explicitly the major obstacles that the group identifies and the action plans suggested to overcome them.

Therefore, both responses to Question II and to Question III have been organized into seven groupings, or categories. For Question II we are asking for an assessment of the importance of the problems listed in each category. For Question III, the proposals for action, subsumed under the same seven categories, are presented for the group's evaluation and comments.

As in Questionnaire 1, we would like to emphasize that the term computer-assisted instruction (CAI) will be used as a generic term, comprising all aspects of the utilization of the computer in an instructional context. Included within the scope of the term as used in this study will be what some have preferred to call computer-augmented instruction, computer-managed instruction, computer-based education, and also problem-solving, gaming, simulation, etc.

QUESTION I

IN WHAT WAYS DO YOU BELIEVE THAT THE USE OF COMPUTERS IN INSTRUCTION WOULD IMPROVE THE EDUCATIONAL PROCESS?

The responses to Question I from the first questionnaire indicate a high degree of unanimity among respondents. There is substantial agreement that the suggestions (listed below) for using the computer in instruction are on the whole highly desirable and that the computer's role in implementing these suggestions could be a significant one.

Because of the high degree of accord we have simply tabulated responses to Question I items below. The data are presented as bar graphs indicating, for every item, the number of responses in each category. They are ranked in order of the mean response (averaged over A and B). Please examine the data and indicate on the reverse side of this sheet any disagreement you might have with the group rating.

Finally, please rate the last three items. These are new items suggested by a number of respondents in Questionnaire 1 as being particularly important and desirable.

	A Desirability: not desirable (1)	slightly (2)	moderately (3)	very (4)	extremely (5)	B Computer's role: no contribution (1)	little (2)	moderate (3)	substantial (4)	extreme (5)
1. Would provide instant feedback, with the result of more efficient learning.				■					■	
2. Would enable student to proceed at own rate, without pressure of lockstepping.				■					■	
3. Would facilitate flexibility of learning program with regard to time and place; e.g., courses could be made available in public libraries for working adults, or in homes.				■						■
4. Would free the teacher from the more routine, drill-and-practice aspects of teaching.				■						■
5. Would make possible immediately available records on students' learning history, facilitating greater individualization.				■						■
6. Would encourage a more freely questioning attitude by removing fear of making errors or asking inappropriate questions.				■					■	
7. Would help to insure bias-free educational environments for minority groups.				■					■	
8. Would shift the emphasis in student evaluation toward attainment of objective learning criteria and away from placement in a normative curve.				■					■	
9. Would provide a more controlled learning environment; student not as subject to the negative influence of poor teaching.				■					■	
10. Would enable student to select his own learning sequence.				■					■	
11. Would free student to concentrate on material to be learned without pressure of competition from peers.				■					■	
New Items:										
1. Would provide for more highly interactive interchange between student and body of subject matter whereby the student would interrogate and explore, rather than assimilate information from a teacher.										
2. Would enable students to work with problems in systems of realistic complexity; i.e., in sciences, business, engineering and medicine.										
3. Would make it possible for educational programs to be more accurately and significantly evaluated, allowing systematic revision of course material to optimize teaching effectiveness.										

QUESTION II

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

We have consolidated responses from Question II (and Question III) into the seven categories listed below:

A. DEMONSTRATION
B. RESEARCH AND DEVELOPMENT
C. INCENTIVES/DISTRIBUTION
D. EDUCATIONAL SYSTEMS AND THE TEACHER
E. SOFTWARE AND HARDWARE
F. COST
G. RE-DIRECTION OF CAI

Each category consists of the original items rated in Questionnaire 1 as well as new items suggested by respondents in the first round. As in Question I, items rated in the first round are presented in rank order of importance with bar graphs of the frequency distributions of responses. Items without frequency distributions are the new items.

Please rate both the old and the new items by checking the appropriate category, using the same scale as in Questionnaire 1.

1 = unimportant factor
2 = slightly important factor
3 = moderately important factor
4 = very important factor
5 = extremely or critically important factor

Once again, please indicate on the reverse side of the sheet any disagreement you might have with the group rating.

A. DEMONSTRATION

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Lack of carefully planned broad programs of CAI experimentation in actual school settings.			■	■	
2. Too few examples of high quality use, at least in the eyes of persons expert in the discipline and in teaching that discipline. Perhaps too much attention to technology and not enough to substance.					
3. Lack of compelling evidence that CAI is more effective than other methods of comparable cost.					
4. Lack of "critical mass" in setting up programs.					
5. Failure to design curricula and systems for high-impact, low-resistance "markets" where real institutional problems can be solved.					

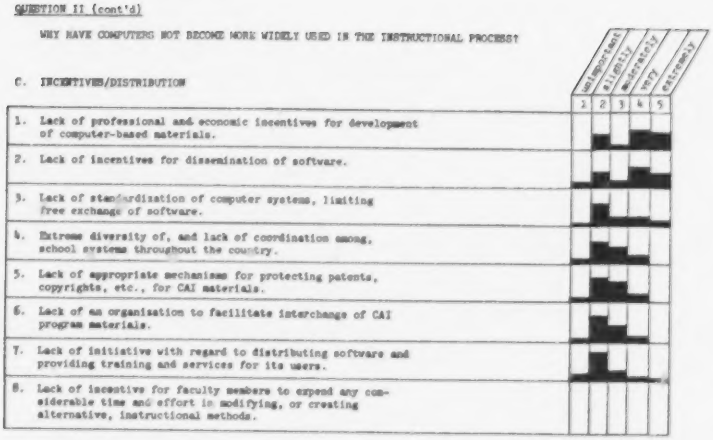
B. RESEARCH AND DEVELOPMENT

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Lack of a simple author language which would enable teachers to prepare effective programs without extensive training.		■		■	
2. Lack of experimental data and theories in learning psychology which would facilitate the design of effective CAI programs appropriate to each age level.		■	■		
3. The lack of personnel with appropriate training and talent in the diverse disciplines required; i.e., instructional psychology, computer science, engineering, educational administration, radio-TV-film.					
4. Limited number of instructional subjects in which CAI can be effective - e.g., math, spelling, but not history, writing.					

QUESTION II (cont'd)

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

C. INCENTIVES/DISTRIBUTION


unimportant
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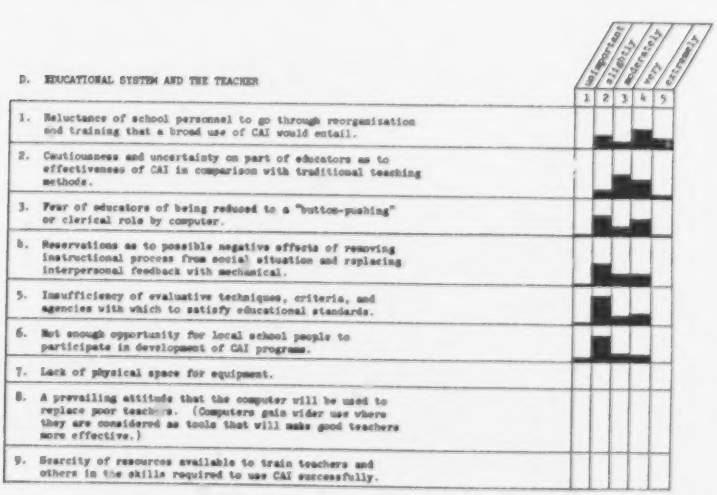
1. Lack of professional and economic incentives for development of computer-based materials.
2. Lack of incentives for dissemination of software.
3. Lack of standardization of computer systems, limiting free exchange of software.
4. Extreme diversity of, and lack of coordination among, school systems throughout the country.
5. Lack of appropriate mechanisms for protecting patents, copyrights, etc., for CAI materials.
6. Lack of an organization to facilitate interchange of CAI program materials.
7. Lack of initiative with regard to distributing software and providing training and services for its users.
8. Lack of incentive for faculty members to expend any considerable time and effort in modifying, or creating alternative, instructional methods.

D. EDUCATIONAL SYSTEM AND THE TEACHER


unimportant
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5
1. Reluctance of school personnel to go through reorganization and training that a broad use of CAI would entail.
2. Cautiousness and uncertainty on part of educators as to effectiveness of CAI in comparison with traditional teaching methods.
3. Fear of educators of being reduced to a "button-pushing" or clerical role by computer.
4. Reservations as to possible negative effects of removing instructional process from social situation and replacing interpersonal feedback with mechanical.
5. Insufficiency of evaluative techniques, criteria, and agencies with which to satisfy educational standards.
6. Not enough opportunity for local school people to participate in development of CAI programs.
7. Lack of physical space for equipment.
8. A prevailing attitude that the computer will be used to replace poor teachers. (Computers gain wider use where they are considered as tools that will make good teachers more effective.)
9. Scarcity of resources available to train teachers and others in the skills required to use CAI successfully.

QUESTION II (cont'd)

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

E. SOFTWARE AND HARDWARE

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Lack of readily available and good computer-based educational materials.					
2. Dissatisfaction with design of presently available terminals.					
3. Unreliability of hardware, in terms of frequent breakdowns due to heavy use by students and insufficient servicing.					
4. Limitations in the kind of student inputs interpretable by the computer.					
5. Lack of readily available and appropriate hardware systems.					
6. Use of systems in which fixed information is funneled through computer's core storage and central processor instead of being maintained in highly accessible low-cost media such as magnetic tape, audio tape, video tape, etc.					

F. COST

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. High capital investment even where good cost-effectiveness can be achieved in the long run.					
2. Poor cost-effectiveness, to date, of computer-based instruction.					
3. Fact that CAI is an add-on cost, not reducing instructional budget, and requiring additional programming personnel.					

G. RE-DIRECTION OF CAI

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Failure to recognize that material must be completely reorganized and restructured if it is to be taught effectively with computer systems.					
2. Application of the "textbook" or single-author model to curriculum production instead of the "movie production" model involving a highly skilled differentiated team.					
3. Tendency to put too much "on the computer" rather than share the presentation and testing of curriculum objectives with other instructional media.					
4. Inadequate development of a range of computer-based pedagogical techniques. The range might include question-answers, tutorial, drill and practice, simulations, games, problem solving modes, etc.					

QUESTION III

WHAT NEEDS TO BE DONE TO TAP MORE FULLY THE POTENTIAL CONTRIBUTION OF THE COMPUTER TO THE INSTRUCTIONAL PROCESS?

A large number and variety of suggestions were received in response to this question. As in Question II, we have organized them into the following seven categories:

A. DEMONSTRATION
B. RESEARCH AND DEVELOPMENT
C. INCENTIVES/DISTRIBUTION
D. EDUCATIONAL SYSTEMS AND THE TEACHER
E. SOFTWARE AND HARDWARE
F. COST
G. RE-DIRECTION OF CAI

As there is too much material for every participant to cover, we are asking you to do the following.

First, select the three (or more if you wish) categories in which you have the most expertise or in which you are most interested. Rate each suggestion in the selected categories using the following scale:

1 = unimportant
2 = slightly important
3 = moderately important
4 = very important
5 = extremely or critically important

You will notice that the suggestions differ widely in their scope, some being quite specific and others much more general. Although this may make some comparisons difficult, we are nevertheless interested in a rough indication of which suggestions are the most important in each category.

Secondly, critically examine the categories you select and suggest any restatements, additions, or deletions that you feel would make the items more precise and more meaningful in substance. Please use page 10 for your comments. If you disagree strongly with an item, make a note of your reasons for disagreement.

A. DEMONSTRATION

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. If CAI can come to have powerful results for Black, Puerto Rican, and Mexican American children, this will provide an enormous incentive for its use.					
2. Mount one critical-mass-size experiment that would demonstrate the economic competitiveness of the computer in instruction.					
3. More education goes on outside of the education establishment than in it. Demonstrate in the military, governmental, or private sector (where clear-cut instructional goals exist) the efficiency of CAI and then it will seep into the educational establishment.					
4. Working CAI-based model schools need to be developed that show how schools can incorporate CAI.					
5. CAI needs direct Federal contracts to support the development of several complete programs, each involving the participation of a university, a school system, and a producer or publisher of educational materials. There will be little progress until there is a body of actual material with which to experiment and to demonstrate. And the costs of preparing initial materials are so high and the investment so risky that other sources of the substantial investment involved are unlikely.					

QUESTION III (cont'd)

WHAT NEEDS TO BE DONE TO TAP MORE FULLY THE POTENTIAL CONTRIBUTION OF THE COMPUTER TO THE INSTRUCTIONAL PROCESS?

B. RESEARCH AND DEVELOPMENT

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. There is a need for trained instructional design personnel who would be familiar with the specifications of needs, goals, performance objectives, with behavioral analysis, planning of system architecture, flowcharting, use of instructional paradigms, use of computer aids to each stage of the instructional design process, with author input systems, including pre-processors and macro expanders, and with ways of communicating both with authors and with production personnel.					
2. The computer provides instrumentation for a new psychology of instruction which departs from the models and paradigms familiar in experimental psychology. New models must be developed and disseminated to researchers throughout the country.					
3. Development is needed of methodologies and techniques that allow the faculty to analyze the basic concepts in their fields and organize these into useful modules that can be effectively presented with computer support.					
4. CAI's inability to tolerate much latitude in student responses gives it a rigidity unsuited to many subjects. A considerable investment should be made in artificial intelligence, with the objective of enabling the computer to accept and analyse free-form student responses or questions.					
5. Our present knowledge of individual differences does not begin to put us in position to take real advantage of the computer's potential. The most urgent need is for extensive research into (a) testing techniques able to make fine discriminations of achievements, potentials, response patterns, learning patterns, etc.; and (b) the development of differentiated sequences of materials responsive to the individual patterns revealed.					

C. INCENTIVES/DISTRIBUTION

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Financial incentives for teachers to take training courses in the use of CAI.					
2. The identification and production of hardware and software for mass markets will provide necessary economic incentives. This leaves the problem of professional incentives however.					
3. Annual national awards for best CAI programs.					
4. Federal funds should subsidize discipline-based groupings (like the NSF-sponsored Commissions on College Physics, Geography, etc.) which ought to draw upon the most prominent members of the discipline to assist in the development of materials that make full use of the computer's instructional capability in the discipline.					
5. The establishment of graduate programs in disciplinary departments oriented toward teaching rather than research would be a major - indeed critically important - step toward advancing the development of educational innovations.					
6. It would be a helpful step for government or private agencies to make financial incentives available, at least initially, for potential writers of CAI programs.					

QUESTION III (cont'd)

WHAT NEEDS TO BE DONE TO TAP MORE FULLY THE POTENTIAL CONTRIBUTION OF THE COMPUTER TO THE INSTRUCTIONAL PROCESS?

D. EDUCATIONAL SYSTEM AND THE TEACHER

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Conversion of our general educational system to allow for greater use of individualized instruction techniques.					
2. It is necessary to construct full curriculum units in which computer usage plays an intrinsic part, because without this, teachers are forced to tear apart a curriculum, insert computer activities, and reconstitute the curriculum - a task for which teachers have no time.					
3. The teacher who uses somebody else's textbook can still take the view that he is giving his own course. With CAI materials, this satisfaction becomes more tenuous. It might be well to study how CAI materials can be prepared with a sufficient number of options for the adopting teacher to sustain the position that his course is essentially under his own intellectual control.					
4. Very little progress is likely to be made unless the teacher training institutions enter CAI in depth and with a degree of professional confidence. This would have to include practical training in the actual use of the hardware, an understanding of the software, and the techniques of integrating CAI with the traditional education process.					
5. Summer workshops in CAI ought to be provided for teachers, similar to those supported by NSF, however, involving hands-on experience with available systems.					
6. The viewpoint should be adopted that major program development will be centered in the schools. Teachers ought to be encouraged to come up with ideas and programs which they can immediately put into practice.					
7. Courses in individually prescribed instruction and small-group tutoring should be provided in every school of education. Educators would find it easier to adapt to computer-based systems as a result of having a more appropriate background, while at the same time schools would not feel they were making an irrevocable investment in CAI.					

E. SOFTWARE AND HARDWARE

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. It is essential for the producers of software to agree on a format that will make it usable in interchangeable hardware. This calls for considerably more self-policing of the industry than exists at present. The alternative is a scattered effect that will make no lasting impact on mass-education and the mass-market.					
2. Analytical research is needed to identify relative importance of different types of hardware interface; i.e., keyboards, c.r.t., audiovisual, etc.					
3. There are two hardware requirements if we are to enhance our capability to present fixed information without passing it through the central processor of a computer. These are: (1) a high volume random access audio unit for use with a computer in teaching reading and languages primarily, and (2) a computer terminal which makes use of the video cassette principle now beginning to appear for the home market.					
4. Consideration needs to be given to well-designed and versatile student terminals. Most current terminals are ugly and unpleasant to use, giving the wrong "image" to computer usage.					
5. A break-through is needed in the development of auxiliary computer storage and presentation devices.					

QUESTION III (cont'd)

WHAT NEEDS TO BE DONE TO TAP MORE FULLY THE POTENTIAL CONTRIBUTION OF THE COMPUTER TO THE INSTRUCTIONAL PROCESS?

F. COST

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Cut the cost of central processor time to the neighborhood of 20¢ per hour per part.					
2. A cost-sharing program for school districts and learning centers installing a computerized program. This might be done on the basis of, say $2 per hour, for each hour of student use on a terminal.					
3. The combination of large time-sharing computers and cable TV may offer relatively low-cost CAI application. Efforts need to be aimed at developing appropriate hardware.					
4. Cost breakthroughs resulting from utilization of existing communications equipment. For example, conversion of existing electric typewriters into consoles, ditto TV's, etc.					
5. There ought to be an extensive and coordinated effort to bring down the cost of CAI equipment by applied research. Computer-based materials should be able to compete economically with other learning media, i.e., books, blackboards, etc.					

G. RE-DIRECTION OF CAI

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
1. Greater emphasis on a wide range of computer support for learning and much less focus on the tools provided by traditional CAI (tutorial, drilled practice, etc.).					
2. Many of the applications of the computer to education have been pedestrian or have involved tasks that might well have been accomplished through relatively inexpensive but well-prepared programmed texts. We should be doing more frontier work and less gimmickry.					
3. Education is not likely to force computing costs downward any more rapidly than other markets for computers are now forcing costs downward. Therefore, education would be better advised to concentrate on unique needs in computing hardware and software and simply wait out the cost problem. Tutorial CAI and drill and practice CAI are now cost-justified in only special instances such as remedial education, special central-city situations, etc. Computers can be cost-justified now for use in problem solving in schools, for data processing education, for simulation and games, and for certain computer-managed instruction applications.					
4. Simulation is the single area where the computer can provide something which cannot be provided by other instructional means. There should be a greater concentration of effort on the development of simulation materials, for which there is a substantial market potential.					
5. In view of the critical reading retardation problem, especially manifest in urban minority children, major concentration should be on designing two or three alternative CAI programs aimed directly at this specific problem. The social needs are greatest there, and the resources for funding research and development are greatest there. Moreover, successes in this sector would attract much fuller support for other applications of CAI.					

QUESTION III (cont'd)

Note: Please use additional sheets, or the reverse side of this sheet, if you wish.

Restatements, additions and other comments:

_____ _____

Signature Date

EDUCOM

INTERUNIVERSITY COMMUNICATIONS COUNCIL, INC.

Post Office Box 364 · Rosedale Road, Princeton, New Jersey 08540 · Telephone 609-921-7575

QUESTIONNAIRE 3

Study of Factors that have Inhibited a More Widespread Use of Computers in the Instructional Process

Attached is the third and final questionnaire in the sequence being used in this study. It is based on the responses of the thirty participants to the preceding two questionnaires. In it are represented, in summarized form, the group's evaluations and judgments in the areas that have been brought under consideration. You are requested to react to both majority opinions and dissenting viewpoints in each area.

We wish to emphasize the importance of your comments in enabling us to accurately interpret and represent your point of view, and encourage you to comment freely and critically wherever possible.

The questionnaire is divided into three sections. The first presents a tabulation of responses regarding the desirability of, and the computer's contribution to, a number of possible educational changes resulting from a broader use of CAI. The three new items rated in Questionnaire 2 are included.

The second section deals with the obstacles to CAI acceptance. It presents the group's evaluation of topics in each of the six areas which were examined and rated in Questionnaire 2, and asks for a re-evaluation in light of the group judgment. Also requested are your reactions to comments made by other participants.

The final section concerns your ideas as to what effective actions might be taken to further the growth of CAI, in value and acceptance. You are requested to describe, as explicitly as possible, the ways in which your ideas might be implemented. This section of the questionnaire will partially provide the substance for the conference to be held in November.

As in the preceding questionnaires, we wish to note that the term computer-assisted instruction (CAI) will be used as a generic term, comprising all aspects of the utilization of the computer in an instructional context. Included within the scope of the term as used in this study will be what some have preferred to call computer-augmented instruction, computer-managed instruction, computer-based education, and also problem-solving, gaming, simulation, etc.

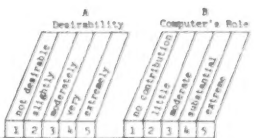
SECTION I

IN WHAT WAYS DO YOU BELIEVE THAT THE USE OF COMPUTERS IN INSTRUCTION WOULD IMPROVE THE EDUCATIONAL PROCESS?

The responses to the new items introduced in the second questionnaire again indicated substantial agreement among respondents regarding the desirability of, and the computer's potential contribution to, the educational improvements considered. Therefore, the data for the new items, (1, 3, and 6) have simply been included among the other items in tabulated form.

The data are presented as bar graphs indicating, for every item, the number of responses in each category. The items are ranked in order of the mean response (averaged over categories A and B).

Please examine the list, and comment on any points which you believe could be improved or with which you disagree. (Use the reverse side of the sheet for comments.)



1. Would enable students to work with problems in systems of realistic complexity; e.g., in sciences, business, engineering and medicine.
2. Would provide instant feedback, with the result of more efficient learning.
3. Would provide for more highly interactive interchange between student and body of subject matter whereby the student would interrogate and explore, rather than assimilate information from a teacher.
4. Would enable student to proceed at own rate, without pressure of lockstepping.
5. Would facilitate flexibility of learning program with regard to time and place; e.g., courses could be made available in public libraries for working adults, or in homes.
6. Would make it possible for educational programs to be more accurately and significantly evaluated, allowing systematic revision of course material to optimize teaching effectiveness.
7. Would free the teacher from the more routine, drill-and-practice aspects of teaching.
8. Would make possible immediately available records on students' learning history, facilitating greater individualization.
9. Would encourage a more freely questioning attitude by removing fear of making errors or asking inappropriate questions.
10. Would help to insure bias-free educational environments for minority groups.
11. Would shift the emphasis in student evaluation toward attainment of objective learning criteria and away from placement in a normative curve.
12. Would provide a more controlled learning environment, student not as subject to the negative influence of poor teaching.
13. Would enable student to select his own learning sequence.
14. Would free student to concentrate on material to be learned without pressure of competition from peers.

SECTION II

In this section, the results of the preceding questionnaires are presented, grouped into the following six categories:

A. DEMONSTRATION
B. COST
C. PRODUCTION/DISTRIBUTION OF CAI MATERIALS
D. EDUCATIONAL SYSTEM AND THE TEACHER
E. RESEARCH AND DEVELOPMENT
F. RE-DIRECTION OF CAI

For each category, you are asked to react to the group data in the following ways:

(1) re-rate each item, commenting where you disagree with the majority opinion,

(2) evaluate the over-all description of problems in each category,

(3) react to suggestions and comments from other respondents.

Instructions for rating:

A slightly different rating format is used in this questionnaire. In each item (see the example below), 'M' represents the median response to the item from Questionnaire 2. The bar indicates the range containing the middle 50% of responses (the inter-quartile range).

Please rate each item again, and comment wherever your rating falls outside the inter-quartile range.

For instance, if you were to check category 1 or category 5 in rating the following item, you are requested to state briefly why you think the rating should be that much lower or that much higher than the majority opinion.

The same scale is used as in the previous questionnaires:

1 = unimportant factor
2 = slightly important factor
3 = moderately important factor
4 = very important factor
5 = extremely or critically important factor

A. DEMONSTRATION

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please re-rate the following, as described in the instructions on page 3.

	unimportant	slightly	moderately	very	extremely
	1	2	3	4	5
A1. Too few examples of high quality use.*				M	
A2. Failure to design curricula and systems for high-impact, low-resistance "markets" where real institutional problems can be solved.					M
A3. Lack of compelling evidence that CAI is more effective than other methods of comparable cost.				M	
A4. Lack of carefully planned broad programs of CAI experimentation in actual school settings.					M
A5. Lack of "critical mass" in setting up programs.			M		

Comment here or on the reverse side of this sheet if your rating does not fall within the range indicated.

Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)

Do you feel that the nature of the problems in this area differs significantly for different levels of education (e.g., pre-college and college)? If so, how?

*This item has been restated. It was formerly "Too few examples of high quality use, at least in the eyes of persons expert in the discipline and in teaching that discipline. Perhaps too much attention to technology and not enough to substance."

A. DEMONSTRATION (cont'd)

WHAT NEEDS TO BE DONE IN THIS AREA TO TAP MORE FULLY THE POTENTIAL OF CAI?

Below are three responses to this question which were the most highly rated in the previous questionnaire (in terms of mean ratings of importance).

a1. CAI needs direct Federal contracts to support the development of several complete programs, each involving the participation of a university, a school system, and a producer or publisher of educational materials. There will be little progress until there is a body of actual material with which to experiment and to demonstrate. And the costs of preparing initial materials are so high and the investment so risky that other sources of the substantial investment involved are unlikely.

a2. Mount one critical-mass-size experiment that would demonstrate the economic competitiveness of the computer in instruction.

a3. Working CAI-based model schools need to be developed that show how schools can incorporate CAI.

Are there other suggestions which you believe are more important than these?

Following are some representative comments from respondents. Please indicate whether you agree or disagree, and comment wherever you feel it is appropriate (use the reverse side of the sheet for additional space).

		Comment if appropriate:
1. "Attempts to implement CAI in schools before it is fully developed might generate a backlash that would seriously affect later development."	Agree__ Disagree__	
2. "More trial and error is needed before CAI is ready for the risk of a large-scale demonstration."	Agree__ Disagree__	
3. "Demonstrations should reflect a wide variety of alternative instructional uses for the computer."	Agree__ Disagree__	

Two additional questions were reflected in comments of a number of respondents. Please provide a brief answer for each:

1. At what level or in what area of education would CAI be initially most effective and most likely to induce a widespread acceptance? (I.e., what are major 'high-impact, low-resistance' areas--see A2.)

2. Which is more critical: the lack of demonstration of high-quality instruction, or of economic feasibility?

B. COST

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please re-rate the following, as described in the instructions on page 3.

		unimportant 1	slightly 2	moderately 3	very 4	extremely 5
B1.	Fact that CAI is an add-on cost, not reducing instructional budget, and requiring additional programming personnel.					M
B2.	High capital investment even where good cost-effectiveness can be achieved in the long run.					M
B3.	Poor cost-effectiveness, to date, of computer-based instruction.				M	

Comment here or on the reverse side of this sheet if your rating does not fall within the range indicated:

Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)

Do you feel that the nature of the problems in this area differs significantly for different levels of education (e.g., pre-college and college)? If so, how?

B. COST (cont'd)

WHAT NEEDS TO BE DONE IN THIS AREA TO TAP MORE FULLY THE POTENTIAL OF CAI?

Below are three responses to this question which received the highest mean ratings, in terms of importance, in the previous questionnaire.

b1. There ought to be an extensive and coordinated effort to bring down the cost of CAI equipment by applied research. Computer-based materials should be able to compete economically with other learning media, i.e., books, blackboards, etc.

b2. The combination of large time-sharing computers and cable TV may offer relatively low-cost CAI application. Efforts need to be aimed at developing appropriate hardware.

b3. Cut the cost of central processor time to the neighborhood of 20¢ per student contact hour.

Are there other suggestions which you believe are more important than these?

Following are some representative comments from respondents. Please indicate whether you agree or disagree, and comment wherever you feel it is appropriate (use the reverse side of the sheet for additional space).

1.	"Ordinary economic ; sures, combined with technological advances, will bring cost of computer and communications equipm ; this is primarily the way that the cost prob e resolved."	Agree__ Disagree__
2.	"'Cost-effectiveness' is not a term which is relevant to present education. It requires specific objectives, which ordinary schools don't have."	Agree__ Disagree__

Comment if appropriate:

C. PRODUCTION/DISTRIBUTION OF CAI MATERIALS

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please re-rate the following, as described in the instructions on page 3.

	1 no improvement	2 slight	3 moderate	4 very	5 extremely	
C1. Lack of readily available and good computer-based educational materials.						
C2. Lack of professional and economic incentives for development of computer-based materials.						
C3. Lack of incentives for faculty members to expend any considerable time and effort in modifying, or creating alternative, instructional methods.						
C4. Lack of incentives for dissemination of software.						
C5. Application of the "textbook" or single-author model to curriculum production instead of the "movie production" model involving a highly skilled differentiated team.						
C6. The lack of personnel with appropriate training and talent in the diverse disciplines required, i.e., instructional psychology, computer science, engineering, educational administration, radio-TV-film.						
C7. Lack of standardization of computer systems, limiting free exchange of software.						
C8. Lack of appropriate mechanisms for protecting patents, copyrights, etc., for CAI materials.						
C9. Lack of initiative with regard to distributing software and providing training and services for its users.						
C10. Lack of an organization to facilitate interchange of CAI program materials.						

Comment here or on the reverse side of this sheet if your rating does not fall within the range indicated:

Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)

Do you feel that the nature of the problems in this area differs significantly for different levels of education (i.e., pre-college and college)? If so, how?

C. PRODUCTION/DISTRIBUTION OF CAI MATERIALS (cont'd)

WHAT NEEDS TO BE DONE IN THIS AREA TO TAP MORE FULLY THE POTENTIAL OF CAI?

Below are three responses to this question which were most highly rated in the previous questionnaire (in terms of mean ratings of importance).

c1. There is a need for trained instructional design personnel who would be familiar with the specifications of needs, goals, performance objectives, with behavioral analysis, planning of system architecture, flowcharting, use of instructional paradigms, use of computer aids to each stage of the instructional design process, with author input systems, including preprocessors and macro expanders, and with ways of communicating both with authors and with production personnel.

c2. It would be a helpful step for government or private agencies to make financial incentives available, at least initially, for potential writers of CAI programs.

c3. Federal funds should subsidize discipline-based groupings (like the NSF-sponsored Commissions on College Physics, Geography, etc.) which ought to draw upon the most prominent members of the discipline to assist in the development of materials that make full use of the computer's instructional capability in the discipline.

Are there other suggestions which you believe are more important than these?

Following are some representative comments from respondents. Please indicate whether you agree or disagree, and comment wherever you feel it is appropriate (use the reverse side of the sheet for additional space).

		Comment if appropriate:
1.	"Purely financial incentives will draw relatively incompetent people into the field. Attention must be given to maintaining professional standards."	Agree__ Disagree__
2.	"The problem of effective distribution of CAI materials and systems will resolve itself once there is a market for such materials."	Agree__ Disagree__
3.	"Local people are generally not qualified to write CAI materials, nor would they have the necessary time. Results would be highly uneven in quality."	Agree__ Disagree__

An additional question arose from comments of a number of respondents. Please provide a brief answer.

1. Who are most likely to be the primary producers of CAI course materials?

D. EDUCATIONAL SYSTEM AND THE TEACHER

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please re-rate the following, as described in the instructions on page 3.

	unimportant 1	slightly 2	moderately 3	very 4	extremely 5
D1. Reluctance of school personnel to go through reorganization and training that a broad use of CAI would entail.			M		
D2. Cautiousness and uncertainty on part of educators as to effectiveness of CAI in comparison with traditional teaching methods.			M		
D3. Scarcity of resources available to train teachers and others in the skills required to use CAI successfully.			M		
D4. Fear of educators of being reduced to a "button-pushing" or clerical role by computer.			M		
D5. Reservations as to possible negative effects of removing instructional process from social situation and replacing interpersonal feedback with mechanical.			M		
D6. Extreme diversity of, and lack of coordination among, school systems throughout the country.		M			
D7. Insufficiency of evaluative techniques, criteria, and agencies with which to satisfy educational standards.		M			
D8. A prevailing attitude that the computer will be used to replace poor teachers instead of to make good teachers more effective.*		M			
D9. Not enough opportunity for local school people to participate in development of CAI programs.		M			

Comment here or on the reverse side of this sheet if your rating does not fall within the range indicated:

Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)

Do you feel that the nature of the problems in this area differs significantly for different levels of education (e.g., pre-college and college)? If so, how?

*This item has been restated. It was formerly "A prevailing attitude that the computer will be used to replace poor teachers. (Computers gain wider use where they are considered as tools that will make good teachers more effective.)"

D. EDUCATIONAL SYSTEM AND THE TEACHER (cont'd)

WHAT NEEDS TO BE DONE IN THIS AREA TO TAP MORE FULLY THE POTENTIAL OF CAI?

Below are three responses to this question which received the highest mean ratings, in terms of importance, in the previous questionnaire.

d1. Conversion of our general educational system to allow for greater use of individualised instruction techniques.

d2. It is necessary to construct full curriculum units in which computer usage plays an intrinsic part, because without this, teachers are forced to tear apart a curriculum, insert computer activities, and reconstitute the curriculum - a task for which teachers have no time.

d3. Summer workshops in CAI ought to be provided for teachers, similar to those supported by NSF, however, involving hands-on experience with available systems.

Are there other suggestions which you believe are more important than these?

Following are some representative comments from respondents. Please indicate whether you agree or disagree, and comment wherever you feel it is appropriate (use the reverse side of the sheet for additional space).

		Comment if appropriate:
1.	"Any CAI system which allows students to proceed at their own rate will create insoluble administrative problems for traditional schools."	Agree__ Disagree__
2.	"CAI program development should be centered in schools so that teachers can actively participate in, and contribute their experience to, the development of ideas and programs."	Agree__ Disagree__
3.	"CAI materials should be prepared with a sufficient number of options for the adopting teacher to sustain the position that his course is essentially under his own intellectual control."	Agree__ Disagree__

E. RESEARCH AND DEVELOPMENT

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please re-rate the following, as described in the instructions on page 3.

	Unimportant 1	Slightly 2	Moderately 3	Very 4	Extremely 5
E1. Dissatisfaction with design of presently available terminals.		M			
E2. Limitations in the kinds of student inputs interpretable by the computer.		M			
E3. Unreliability of hardware, in terms of frequent breakdowns due to heavy use by students and insufficient servicing.		M			
E4. Use of systems in which fixed information is funneled through computer's core storage and central processor instead of being maintained in highly accessible low-cost media such as magnetic tape, audio tape, video tape, etc.		M			
E5. Lack of readily available and appropriate hardware systems.		M			
E6. Lack of a simple author language which would enable teachers to prepare effective programs without extensive training.		M			
E7. Lack of experimental data and theories in learning psychology which would facilitate the design of effective CAI programs appropriate to each age level.		M			

Comment here or on the reverse side of this sheet if your rating does not fall within the range indicated.

Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)

Do you feel that the nature of the problems in this area differs significantly for different levels of education (e.g., pre-college and [illegible])? If so, how?

E. RESEARCH AND DEVELOPMENT (cont'd)

WHAT NEEDS TO BE DONE IN THIS AREA TO TAP MORE FULLY THE POTENTIAL OF CAI?

Below are three responses to this question which received the highest mean ratings, in terms of importance, in the previous questionnaire.

e1. Development is needed of methodologies and techniques that allow the faculty to analyze the basic concepts in their fields and organize these into useful modules that can be effectively presented with computer support.

e2. The computer provides instrumentation for a new psychology of instruction which departs from the models and paradigms familiar in experimental psychology. New models must be developed and disseminated to researchers throughout the country.

e3. Consideration needs to be given to well-designed and versatile student terminals.

Are there other suggestions which you believe are more important than these?

Following are some representative comments from respondents. Please indicate whether you agree or disagree, and comment wherever you feel it is appropriate (use the reverse side of the sheet for additional space).

		Comment if appropriate:
1. "CAI requires a great deal of further development and study through disciplinary research and industrial development before it is refined enough for wide use."	Agree__ Disagree__	
2. "Research considerations are very important in the long-range view, but other factors are of more immediate concern."	Agree__ Disagree__	
3. "Instruction is still an 'art'; instructional theories are irrelevant to making better materials."	Agree__ Disagree__	

F. RE-DIRECTION OF CAI

WHY HAVE COMPUTERS NOT BECOME MORE WIDELY USED IN THE INSTRUCTIONAL PROCESS?

Please re-rate the following, as described in the instructions on page 3.

		unimportant	slightly important	moderately important	very important	extremely important	Comment here or on the reverse side of this sheet if your rating does not fall within the range indicated:
		1	2	3	4	5	
F1.	Failure to recognize that material must be completely reorganized and restructured if it is to be taught effectively with computer systems.				M		
F2.	Inadequate development of a range of computer-based pedagogical techniques. The range might include question-answers, tutorial, drill and practice, simulations, games, problem solving modes, etc.				M		
F3.	Tendency to put too much "on the computer" rather than share the presentation and testing of curriculum objectives with other instructional media.			M			

Do you feel that this is an accurate representation of the problems in this area? (What comments would you add to make the picture more complete?)

Do you feel that the nature of the problems in this area differs significantly for different levels of education (e.g., pre-college and college)? If so, how?

F. RE-DIRECTION OF CAI (cont'd)

WHAT NEEDS TO BE DONE IN THIS AREA TO TAP MORE FULLY THE POTENTIAL OF CAI?

Below are three responses to this question which received the highest mean ratings, in terms of importance, in the previous questionnaire.

f1. Many of the applications of the computer to education have been pedestrian or have involved tasks that might well have been accomplished through relatively inexpensive but well-prepared programmed texts. We should be doing more frontier work and less gimmickry.

f2. In view of the critical reading retardation problem, especially manifest in urban minority children, major concentration should be on designing two or three alternative CAI programs aimed directly at this specific problem. The social needs are greatest there, and the resources for funding research and development are greatest there. Moreover, successes in this sector would attract much fuller support for other applications of CAI.

f3. Education is not likely to force computing costs downward any more rapidly than other markets for computers are now forcing costs downward. Therefore, education would be better advised to concentrate on unique needs in computing hardware and software and simply wait out the cost problem. Tutorial CAI and drill and practice CAI are now cost-justified in only special instances such as remedial education, special central-city situations, etc. Computers can be cost-justified now for use in problem solving in schools, for data processing education, for simulation and games, and for certain computer-managed instruction applications.

Are there other suggestions which you believe are more important than these?

Following are some representative comments from respondents. Please indicate whether you agree or disagree, and comment wherever you feel it is appropriate (use the reverse side of the sheet for additional space).

	Comment if appropriate:
1. "CAI is too expensive now for any uses but specialized ones. More effort should be given to designing high-quality CAI programs for specific educational problems where CAI might be particularly effective, such as remedial education, reading, and calculus."	Agree__ Disagree__
2. "There should be more emphasis on learner control of subject material and style of teaching."	Agree__ Disagree__
3. "There should be more effort directed toward a computer-based system which would provide support for all the instructional and management functions in a school's program."	Agree__ Disagree__
4. "There is not enough leadership in the area of educational change, which is necessary if the potential of CAI is to be fully developed. National centers are needed to do research, to develop resources, to study policy questions, develop strategies, etc."	Agree__ Disagree__

SECTION III

In this section we are requesting your ideas as to specific actions that might be taken to further the growth in value and acceptance of CAI. Select two (or more if you wish) of the six areas considered--ones in which you have the most expertise or are most interested--and describe, in each area, an action plan which you feel would be a significant step toward removing obstacles to CAI's development. You may wish to use one of the three suggestions for actions which are listed in each area in Section II, or you may choose to develop a new suggestion.

In addition to a description of the action plan, include suggestions of the source and level of funding, target population, time projections, and so on.

Your efforts to develop these plans as thoroughly as possible, which we realize is a time-consuming and demanding task, will be very much appreciated. The plans will be used in determining the format, and providing the topics for discussion, in the conference to be held at the end of the study.

ACTION PLAN I

Area:

Description:

Source & Level of Funding:

Target Population:

Time Projection:

ACTION PLAN II

Area:

Description:

Source & Level of Funding:

Target Population:

Time Projection:

_____ _____

Signature Date

Appendix 2

Responses to Questionnaire 3

Following is a summary of responses to the representative comments and questions in Questionnaire 3.

A. DEMONSTRATION

		Total Number of Respondents Agreeing or Disagreeing
1.	"Attempts to implement CAI in schools before it is fully developed might generate a backlash that would seriously affect later development."	Agree 21 Disagree 5
2.	"More trial and error is needed before CAI is ready for the risk of a large-scale demonstration."	Agree 16 Disagree 11
3.	"Demonstrations should reflect a wide variety of alternative instructional uses for the computer."	Agree 19 Disagree 7

1. At what level or in what area of education would CAI be initially most effective and most likely to induce a widespread acceptance? (I.e., what are major 'high-impact, low-resistance' areas—see A2.)

Summary of Responses	Number of Respondents in each Category
Basic skills: math, english	9
a) at pre-college (4)	
b) remedial or introductory in community or junior colleges (3)	
Advanced work at college level	4
Vocational, technical schools	3
Remedial programs for disadvantaged, special ed. children	2
Industrial, military training	2
Combinations of the above	3

2. Which is more critical: the lack of demonstration of high-quality instruction, or of economic feasibility?

Emphasis on economic feasibility	14
Emphasis on quality	8
Both are equally important	4

B. COST

1.	"Ordinary economic pressures, combined with technological advances, will bring down the cost of computer and communications equipment in time; this is primarily the way that the cost problem will be resolved."	Agree 23 Disagree 5
2.	" 'Cost-effectiveness' is not a term which is relevant to present education. It requires specific objectives, which ordinary schools don't have."	Agree 10 Disagree 16

C. PRODUCTION/DISTRIBUTION OF CAI MATERIALS

1.	"Purely financial incentives will draw relatively incompetent people into the field. Attention must be given to maintaining professional standards."	Agree 13 Disagree 14
2.	"The problem of effective distribution of CAI materials and systems will resolve itself once there is a market for such materials."	Agree 21 Disagree 7
3.	"Local people are generally not qualified to write CAI materials nor would they have the necessary time. Results would be highly uneven in quality."	Agree 18 Disagree 8

1. Who are most likely to be the primary producers of CAI course materials?

Academic faculty 7
Private sector, publishers, instructional materials producers, similar to textbook production 7
Teams of specialists, or university-based labs 6
A variety of sources 3

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D. EDUCATIONAL SYSTEM AND THE TEACHER

1.	"Any CAI system which allows students to proceed at their own rate will create insoluble administrative problems for traditional schools."	Agree 7 Disagree 22
2.	"CAI program development should be centered in schools so that teachers can actively participate in, and contribute their experience to, the development of ideas and programs."	Agree 14 Disagree 14
3.	"CAI materials should be prepared with a sufficient number of options for the adopting teacher to sustain the position that his course is essentially under his own intellectual control."	Agree 21 Disagree 5

E. RESEARCH AND DEVELOPMENT

1.	"CAI requires a great deal of further development and study through disciplinary research and industrial development before it is refined enough for wide use."	Agree 16 Disagree 11
2.	"Research considerations are very important in the long-range view, but other factors are of more immediate concern."	Agree 17 Disagree 6
3.	"Instruction is still an 'art'; instructional theories are irrelevant to making better materials."	Agree 5 Disagree 20

F. RE DIRECTION OF CAI

1.	"CAI is too expensive now for any uses but specialized ones. More effort should be given to designing high quality CAI programs for specific educational problems where CAI might be particularly effective, such as remedial education, reading, and calculus."	Agree 22 Disagree 6
2.	"There should be more emphasis on learner control of subject material and style of teaching."	Agree 17 Disagree 10
3.	"There should be more effort directed toward a computer-based system which would provide support for all the instructional and management functions in a school's program."	Agree 19 Disagree 8
4.	"There is not enough leadership in the area of educational change, which is necessary if the potential of CAI is to be fully developed. National centers are needed to do research, to develop resources, to study policy questions, develop strategies, etc."	Agree 22 Disagree 6

Appendix 3

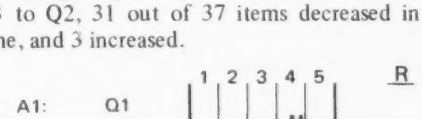
Convergence Data

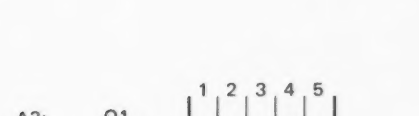
The response distributions of Question II items, over the three questionnaires (Q1, Q2, and Q3), are summarized below. The items are numbered as in Q3, which is presented in Appendix 1. The bars indicate the range for each distribution containing the middle 50% of responses (the interquartile range), with M indicating the median rating.

Items which have only Q2 and Q3 ratings are those which were first introduced in the second questionnaire.

R represents the number of responses which were more than one rating category from the median (M).

Comparing Q2 to Q1, 11 out of 23 items decreased in R values (i.e., had fewer out-of-range responses), 5 remained the same, and 7 increased. Comparing Q3 to Q2, 31 out of 37 items decreased in R values, 3 remained the same, and 3 increased.





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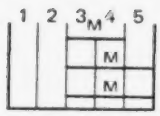
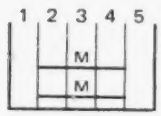
A4:



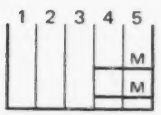
	R
Q1	5
Q2	2
Q3	0

A5:



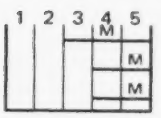
Q1	
Q2	7
Q3	3

B1:



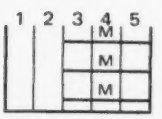
Q1	
Q2	6
Q3	3

B2:



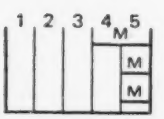
Q1	3
Q2	6
Q3	3

B3:



Q1	5
Q2	2
Q3	2

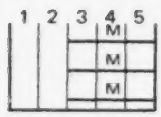
C1:



Q1	6
Q2	0
Q3	2

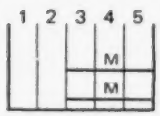
98

C2:



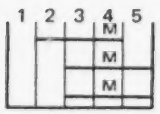
	R
Q1	7
Q2	5
Q3	1

C3:



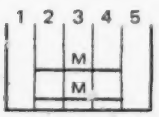
Q1	
Q2	3
Q3	2

C4:



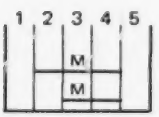
Q1	9
Q2	6
Q3	2

C5:



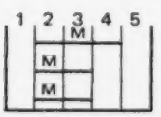
Q1	
Q2	10
Q3	7

C6:



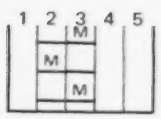
Q1	
Q2	8
Q3	4

C7:



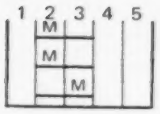
Q1	5
Q2	5
Q3	7

C8:



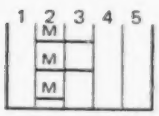
	R
Q1	3
Q2	4
Q3	3

C9:



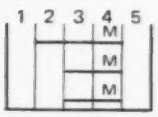
Q1	3
Q2	2
Q3	2

C10:



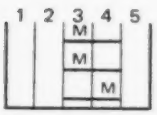
Q1	4
Q2	6
Q3	2

D1:



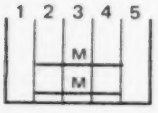
Q1	8
Q2	4
Q3	0

D2:



Q1	1
Q2	3
Q3	1

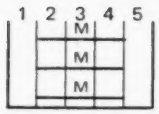
D3:



Q1	
Q2	6
Q3	1

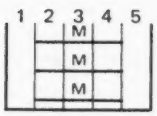
100

D4:



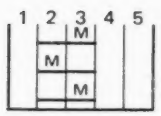
	R
Q1	2
Q2	2
Q3	0

D5:



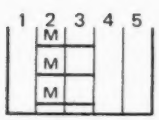
Q1	1
Q2	2
Q3	0

D6:



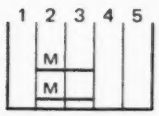
Q1	3
Q2	4
Q3	3

D7:



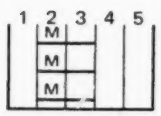
Q1	6
Q2	5
Q3	1

D8:



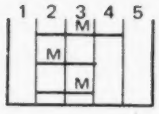
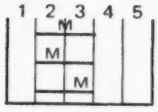
Q1	
Q2	5
Q3	2

D9:



Q1	5
Q2	2
Q3	0

101

			R
E1:	Q1		4
	Q2		6
	Q3		1
E2:	Q1		7
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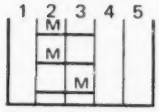
E3:	Q1		6
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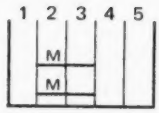
E4:	Q1		
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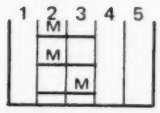
E5:	Q1		5
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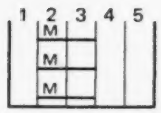

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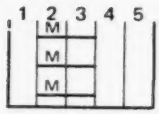

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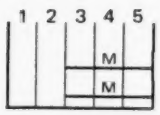

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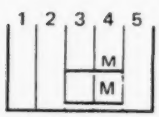

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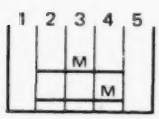

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Appendix 4

Original Action Plans

These are the unedited action plans suggested in response to Section III in Questionnaire 3. They represent the major source from which the action statements (Appendix 5) were drawn.

1. (1)† Thorough integration of CAI into a school curriculum will take (1) development of adequate materials, (2) revised administrative arrangements, (3) special training for teachers, (4) cooperation of parents. As successful demonstrations will necessarily be of substantial scope I would favor working with a state and one or more cooperating school districts. Enough funds must be provided to give adequate lead time, 1 - 3 years, and personnel. Potential benefits to be demonstrated are possible reduction in school costs, improved achievement, and greater flexibility of instruction.

FUNDING: Federal, State, Local – combination to yield approximately $1,000,000 per cooperating unit per year.

TARGET POPULATION: Typical schools.

TIME PROJECTION: 5 - 7 years.

2. (1,5) The basic technology and techniques required for effective use of CAI have been sufficiently outlined through numerous relatively small ad hoc studies to indicate the need for major coordinated programs of research and development. It is clear that the parameters of the CAI *system* are as critical in determining its educational usefulness and economic feasibility as are the items of hardware and the computer programs. A small number of large scale projects should be undertaken which involve coordinated research and application of complete CAI systems serving a statistically significant clientele. The magnitude of such projects would require large commitments of funds for a period of several years.

At least two projects should be developed; one designed around maximum centralization of the information handling machinery with direct lines to each terminal, and the other emphasizing local computational units or "nodes" of computational machinery in an intercommunicating web. These projects should be undertaken through a consortium of industry, universities and communities, and directed initially toward markets of mass application and broad social need such as remedial elementary education (reading, oral and written language usage, mathematics, etc.), vocational training in areas of projected need (service industries such as health care, mechanical maintenance, computer programming, etc.), and college remedial subjects (language facility, mathematics, etc.). These projects could be organized within five categories of activities: (1) system design, (2) hardware development, (3) program development, (4) operation, (5) evaluation.

†The numbers in parentheses refer to the related action statements in Appendix 5.

FUNDING: Federal grants plus industry R & D monies. $10 - $15 million over a five year period for each project.

TARGET POPULATION: lst priority – Urban underprivileged children and young adults. 2nd priority – Other low income, jobless who need vocational training. 3rd priority – General primary and secondary school population.

TIME PROJECTION: 5 years.

3. (1) Support large scale demonstration of CAI feasibility–(NSF's current study with MITRE/TEXAS and Illinois). Two different, competing systems will be implemented, installed and used over a 5-year period, to evaluate the feasibility of each. Each system involves about 500 student consoles in elementary schools, junior colleges, and universities. Additional plans are needed for using these facilities, at the end of the demonstration, for developing new CAI techniques – that is, for establishing a kind of test bed in which new ideas can be tried.

FUNDING: NSF, 5 million dollars.

TARGET POPULATION: Across the board (formal education only).

TIME PROJECTION: 1972-1977.

4. (1) A third large (critical mass) demonstration is needed for instructional use of computers in college curriculum.

U. of Illinois is developing and demonstrating the economic feasibility of a large-scale system; Mitre Corporation and the U. of Texas are doing the same for a medium-scale system. Both are dedicating the planned facility to CAI (special languages, special terminal equipment, etc.) and pursuing new developments in hardware and software to gain cost savings.

A third project should demonstrate the feasibility of extending general-purpose time sharing systems for economical assistance with instruction in colleges (and pre-college?). It may be able to succeed in some aspects where the other projects are likely to encounter difficulties; it may produce software and curriculum which is more immediately useable on a broad scale.

Part of the project (if it is all one project) would involve teleprocessing from a large system to serve a geographical region; part would demonstrate smaller time sharing systems readily reproduceable at new sites in a region; attention would be given to network concepts, especially to promote exchange among users, not necessarily by direct electronic communication. A group of universities and colleges would be involved, providing a broad base of expertise and experience. Innovation in curriculum development, combined with maintaining cost levels, would be emphasized. Includes cooperation with professional societies to adapt materials for use throughout a large region (not typical regional computer services – "networks" – to date).

FUNDING: $3 million; NSF.

TARGET POPULATION: To demonstrate to college administrators and other decision makers that computing assistance can be effective and economical for college students, and may be especially important for students not having large-university learning resources otherwise.

TIME PROJECTION: 5 years, including some diffusion activities.

5. (2) Despite annual meetings and the beginnings of a community of users of computing, most faculty members on the fringes don't know exactly what it is like to bring computing into the curriculum. The project I propose would be a 'travelling circus' that goes from school to school, carrying terminals, plotters, mini-computers, and data acquisition equipment, and gives a thorough and realistic demonstration of

how teachers actually use a computer in their courses. 2 or 3 days at each school, 3 or 4 faculty members, plus supporting cast in each troupe. Two months of action, one of planning each year.

FUNDING: Federal, professional societies– $100,000 per year.

TARGET POPULATION: Curious teachers.

TIME PROJECTION: 3 years.

6. (3) Develop a full CAI program for some subject, or educational level within a subject, in order to demonstrate, if it can be demonstrated, the intellectual and economic feasibility of the technique. It must be of the highest caliber and have maximum flexibility to enable the academic to see his role as an individual with regard to the formatted curriculum. Then demonstrate the effectiveness of the CAI package in a real environment and with something of a fishbowl atmosphere from the perspective of bringing observers in for evaluation purposes. The package should be multi-media and interactive to the extent possible. The entire operation should be completely debugged and tested before it sees the light of day and scrutiny should be invited from the doubters. Above all, the demonstration should be *significant,* not gimmicky, and use the computer only where it has a real advantage over manual techniques.

FUNDING: 1) The Federal government – after all, it's only a prototype of an educational SST.
2) Foundations.
3) A consortium of industrial grants.

TARGET POPULATION: Academic peer group, school administrators, legislators.

TIME PROJECTION: 5 years.

7. (5) Set up a cooperative project involving a community college system (Dade County, Fla., and St. Louis are good possibilities) and a major commercial producer of educational materials, with professional collaboration of retained outside experts, to develop, test, and demonstrate a remedial course in English. This is a basic and nearly universal need. Many community colleges and other open-enrollment public institutions are frustrated in many aspects of their educational program by the inadequate reading comprehension, writing, and oral skills of their students. Correcting this is a first objective of nearly all such institutions. They are very receptive to new approaches. Because they do not recognize remedial English as a job they ought to have to do or want to do, there is no vested interest in existing methods. Any staff now engaged in remedial English instruction would be glad to be relieved to go on to more advanced work. There is relatively little cake of custom to be broken. And community colleges are expanding rather than contracting and usually in a position to spend money for promising innovative systems and materials.

Moreover, this is a field in which computer-assisted instruction seems to offer unusual promise. Hence the project combines social need, market responsiveness, teacher acceptance, and probable operational success.

The project would design a course, prepare the programs and materials, including related conventional print and audio-visuals for follow-up and reinforcement, and test and refine them through two academic years. As success is achieved, in the second and third academic years the program could become a demonstration center in which the methods and materials could be studied for adoption or adaptation elsewhere and for guides as to techniques for programs in other disciplines or at other levels.

Once the program had reached an appropriate and tested level of development, the participating educational materials publisher would be responsible for putting it into

final marketable form, producing it, and marketing it to community colleges, other open-enrollment institutions with comparable problems, and high schools. A part of the project, however, would be short, intensive teacher-training institutes to prepare faculty to use such materials.

This project would be the most effective wedge I can think of to produce a solid and accepted success from which we could build out in a variety of directions.

FUNDING: Federal grant (to community college system) and contract (with publisher) of approximately $750,000 to $1,000,000 plus contribution of services and facilities by the community college system and substantial investment by the publisher.

TARGET POPULATION: Community college entrants and high school students in need of remedial English.

TIME PROJECTION: Two years for development, one for demonstration and production, one year or two for assistance in dissemination through funded teacher training institutes.

8. (6) Let's assume we can cost-justify *one* modest computer in a fair-sized high school or college. Let's get as much payroll/inventory on it as we can; let's tie it into vocational ed. and science ed. for demonstration purposes. Now let's design (a) a cheap time-sharing system for it, (b) use plasma display terminals, (c) get a team to design materials around this cost/capability constraint-set. For example, this means a limited number of terminals, used in shifts, perhaps with night school use as well, probably just one room with terminals, like the calculator room; probably students could be trained to do almost all servicing (vocational ed.). The big goal would be to increase efficiency. To do this we first need a very careful analysis of exactly what the computer can do that a programmed text can't do as well or nearly-as-well-for-less.

9. (7) Organize a national effort to create two or three alternative CAI programs aimed at the correction of reading deficiencies in elementary school children. Arrange for large-scale geographically dispersed trials of the course under teachers who have attended summer institutes on the course. Measure the time required by each student to attain a specified performance level, and compare that time with conventional course duration. Assemble complete cost-effectiveness data.

FUNDING: U.S. Office of Education; private foundations. $2 to 5 million.

TARGET POPULATION: Elementary school children with reading difficulties, especially in urban minorities.

TIME PROJECTION: Planning study (1 year), course development and teacher training (2 years), and trials (2 years) = total of 5 years.

10. (8) Support a special experimental demonstration program relating to the U.S.O.E. Right to Read program, and centering on the lack of functional literacy skills possessed by many inner-city, young adults between the ages of 16 and 25. A new Computer-Assisted, -Based, and -Managed Adult Education Success in Reading Program based on innovative hardware, newly-funded software development, and proven multi-media and learning psychology would be appropriate.

FUNDING: U.S.O.E.: $5 million funding for 3-year program.

TARGET POPULATION: The remedial open-enrollment city university group, plus Regional Opportunity Career Development Centers.

TIME PROJECTION: 1972-1974.

11. (9) The objective of this plan is to develop a computer-managed system for instruction in mathematics, grades 7-12. A school system would be identified and asked to submit behavioral objectives in mathematics for students in courses being taken in grade levels 7-12. The objectives would be arranged in Gagne type learning hierarchies. Sample test items keyed to these objectives would be either randomly generated by the computer in Honeywell's Arithmetic Test Generator (ATG) program or they would be selected from pools of test items keyed to the objectives. A diagnostic and computer management system would be developed to build around these objectives. The interface with the computer would be with optical scan card readers located in the schools. Printed materials in quantity would be produced at a central location and sent on to the schools by mail. As the system develops, the learning materials being used in the schools would be adapted to the system and new materials developed where necessary. The school system should be willing to contribute hardware and software for the ongoing operation of the system with the funding of the project being utilized primarily for development purposes. Such a project would have a high probability of success because in the field of secondary mathematics is where the teachers have been most receptive to CAI. If a school system has an investment in money and faculty input into the system, there is a high probability that the program will continue after outside funding is discontinued.

FUNDING: NSF or OE – $200,000 per year.

TARGET POPULATION: Secondary mathematics students.

TIME PROJECTION: Five years.

12. (12, 26) Special education has high needs for individualized, highly effective instruction. Also has a deficit of teaching personnel. Program would have 2 phases:

1) Development of courseware to train teachers in how to identify and prescribe for different conditions.

2) Targeted courseware development for teaching the deaf to read and write (communicate in writing or typing). Would develop basic knowledge of human info-processing in a pathological situation in which variables are exaggerated. Product would meet tough social problems, add basic knowledge to programming for normals.

FUNDING: Probably O.E. – $3.5 million for 4 years.

TARGET POPULATION: Special Ed. teachers and handicapped students, grade 6 to adult.

TIME PROJECTION: 4 years.

13. (13) Begin with groups of high-school students who are oriented toward teaching. Give them extensive opportunities to work with computers in their own instruction and also in the development of programs. Let them participate in production of hardware. Follow up their interest and competence in their collegiate teacher training experience.

FUNDING: Local and Federal, with possible industry subsidy.

TARGET POPULATION: High-school students

TIME PROJECTION: Continuing program. Approx. 6 years for each group.

14. (14) Support a special experimental demonstration program to prepare talented Job Corpsmen in the fundamentals of computer technology. The goal of the program would be career preparation for jobs as machine operator, junior programmer, etc. New, advanced concept multi-media software would be part of the development.

FUNDING: Department of Labor: $5 million funding for 3-year program.

TARGET POPULATION: Male and female, GED level Job Corpsmen and Corpswomen.

TIME PROJECTION: 1972-1974.

15. (15) Select a para-professional subject (X-ray techniques, police management, assistance programs for the aged) in which the objective is the acquisition of measurable performance in the student.

Organize a national effort to create a computer-assisted course in the selected subject. Engage the assistance of experienced teachers, and obtain the support of professional groups whom the students will serve after completion of their course.

Arrange for large-scale geographically dispersed trials of the course under teachers who have attended summer institutes on the course.

Measure the time required by each student to attain a specified performance level, and compare that time with conventional course duration. Assemble complete cost-effectiveness data.

FUNDING: U.S. Office of Education; private foundations. $2 to 5 million.

TARGET POPULATION: Community college and open university.

TIME PROJECTION: Planning study (1 year), course development and teacher training (2 years), and trials (2 years) = total of 5 years.

16. (17) For a long time I've wondered if children would learn to read faster if they were provided with a restricted vocabulary and a set of typewriters which could communicate by pairwise interaction, through a central switching device. Restricted to typing messages to friends and reading friends' replies, that is, allowed to communicate, but only by typing, they might learn to read very quickly (having an incremental expansion of the allowable vocabulary). It is an experiment that could be done relatively easily, and if it were successful, could provide a new mode of learning to read.

FUNDING: I don't have ideas about funding.

TARGET POPULTION: 5 - 7 year olds.

TIME PROJECTION: Experiment could be carried out in a few months, once hardware was constructed.

17. (18) Appropriate CAI, using time-shared terminals, could provide the possibility of structured interaction between different classrooms in the same school, or even more important, different schools. This could be done through the use of computer-based games in which a class in one school would challenge a class in another school. The major problem to be overcome is the danger that participation would be limited to a few in each class. Consequently, the games would have to be especially well-designed, requiring contributions from every member of the class in order for the class to take its action on the terminal.

Such a possibility as this could provide a good teacher with great opportunities for freeing the classroom from the constraints of the four walls and restricted interaction that currently characterizes it.

18. (19) For several years, a limited use of simulation and gaming as a part of the education process has been made. Probably the most well known simulations are the business games used in business schools and industrial management training courses. In addition, however, simulation has been used to teach strategy to military person-

nel and to teach civics and foreign policy to secondary school students. Other uses undoubtedly exist of which I am unaware. Considerably more development is needed to exploit the possibility of this approach to using computers in education. It is my belief that simulation represents the single most powerful use of the computer in education. It is the only area of which I am aware in which the computer can provide a depth of understanding impossible by any normal teaching method. I suggest that a task force be established, probably under the direction of the US Office of Education, to establish a strategy for the development and exploitation of the use of simulation. Results should include a list of projects which the computer industries and educational researchers should be encouraged to undertake.

FUNDING: The only additional funding required would be the cost incurred by the USOE. Therefore, projects should be funded by the participants based upon market justification or justification as a valid educational research project.

TARGET POPULATION: Students at all levels with the greatest emphasis at the secondary school level and above.

TIME PROJECTION: The strategy and planning effort should begin immediately with the computing industry encouraged to market resulting products as soon as feasible.

19. (21) Effort is needed in the "applied" research area of testing the relative effectiveness of various pedagogical techniques (drill and practice, simulation, tutorial, etc.) that are computer-based in relation to the material to be taught. Clearly different techniques have differing degrees of effectiveness depending on the degree of structure inherent in the material, the material's complexity and the like. On top of these two factors of course there is the question of the style of the student and the impact this has on the methods of learning that are most effective for him. The goal of the project would be to do enough experimenting to understand the dimensions of these three factors so we would be in a position to design the more effective CAI systems.

FUNDING: Foundation or Government – $200,000 per year for 3 years to each of 10 universities.

TARGET POPULATION: University undergraduate or masters.

TIME PROJECTION: 3 - 4 years.

20. (22) What is essential is not to ask how CAI can become more widespread, but what are the central problems of education now, and how can CAI contribute to their solution.

One central problem is the fact that elementary and secondary schools are now used largely as custodial institutions, and this, coupled with decreasing opportunities for responsible action outside the schools makes students far more irresponsible than they would otherwise be. Whether CAI can contribute to the solution of this problem (which manifests itself as "discipline problems", teacher dissatisfaction and loss of control, and race-related disruptions in schools) is not at all clear. But an effort should be made, because if successful, this would contribute to solution of major school problems.

One possible direction involves the combination of individual student-paced learning on CAI in which the completion of a specified task or unit is not merely followed by more of the same but by a different kind of activity, which would be student-selected. The general idea is that when a student completes a certain amount of work (i.e., reaches a certain achievement level), he gets the possibility of using his time much more fully at his own discretion. He still must make his choice from among a certain set of activities that contribute either (a) to his own learning; (b) to the

school's corporate goals; or (c) the community's welfare. This freedom and opportunity to act responsibly should provide the incentive to proceed rapidly in the self-paced learning.

This would imply two kinds of organization of the school. In one, the teacher's role is reduced to that of monitor and aide, to help out when and where problems arise with self-instruction. At the same time, most teachers would be leading activities of types (b) and (c) above, either those which contribute to the school's goal or those which contribute to the community's welfare.

21. (23) There is a need for basic research into the question of how humans learn. A project of direct operational use to those in the CAI field is the development of a model of the learning process. If we are clear on the major variables involved in how people learn then we have a base from which to design systems that will improve that process. This is obviously a hard task but one that may be tractable if we view it from the standpoint of a learning model to give us insight into the uses of CAI, rather than a completely general purpose model.

FUNDING: Foundation or Government – $500,000 to $1,000,000 per year for 5 years to 3 or 4 universities.

TARGET POPULATION: –

TIME PROJECTION: 5 - 6 years.

22. (24) 1) To conduct research on basic problems relating to the generation of instructional materials and tests by a computer with minimal input demands on the author; 2) to relate these findings directly to the development of courses and areas in which the effectiveness of the materials can be evaluated; and 3) to conduct a cost-benefits analysis of the results.

To illustrate the approach assume that the objective to be achieved by a lesson was to teach a vocabulary (technical or foreign). The author would be required to input his data base – the terms and definitions – and a set of parameters defining the form of presentation and conditions of learning. E.g., dropout procedure, correction (limit 3), 80% criterion (no misspellings), 12 word lists. The system would operate on his database and produce a CAI program as specified without further work by the author and without the need to "debug." Gagne's eight types of learning tasks would be used to provide the taxonomy used in developing each of a set of eight generators, one per type of learning. Each generator would allow the author options and, where data permitted it, the options would be selected for inclusion on the basis of data reported in the research literature. Other aids would provide "readibility" analyses of text so materials would be graded for difficulty and guides to authors so they could reduce the level of difficulty to fit the targeted students. Tests would be generated from text.

FUNDING: NSF or USOE, $175,000 to $200,000 for 5 years.

TARGET POPULATION: Health sciences and teachers in the health sciences, including paraprofessionals.

TIME PROJECTION: Five years. Each of the three efforts – lesson generator, analytical tools, and test generator – would be developed concurrently but not at the same rate. Each, in order indicated, would be completed in a cycle for each of the eight types of learning before the next set was developed. Cost benefit analysis would be performed upon the completion of a set of lessons involving each of the eight types of learning. Two types of learning would be completed in each of the first 3 years and the last two types of learning would each be completed in the fourth and fifth years, respectively.

23. (29) Students and administrators have demonstrated considerable interest and acceptance of CAI; teacher interest and follow-through is low. There is need for intensive teacher training,

a) as part of preparation – on an optional basis,

b) in-service training.

The NSF model of summer workshops would probably be most effective, but short term school system sponsored courses could be just as effective and would demonstrate (to the teacher) the system's interest in CAI work in classroom.

FUNDING: Summer programs – probably state or national – (NSF).

TARGET POPULATION: Classroom teachers – minimum of two per participating school (*not system*) building.

TIME PROJECTION: Could and should be started *now* and continue with a series of programs moving into advanced. Could effect students within a year as teachers and trainers.

24. (30, 88) Attempting to work with individual schools on an experimental basis (with or without government subsidies) to reassure teachers, learn their true concerns and meet them would be promising. Perhaps this has already been done. A few striking positive demonstrations of meeting teacher and institutional resistance ought to be most worthwhile.

25. (31) Establish a series of in-school demonstrations – training centers throughout the country. The centers would be two-purpose: 1) practical demonstration of effective CAI with elementary and secondary school students, 2) training centers for teachers from other schools who could see practical application of the techniques they are expected to learn and take back to their own schools. I would favor training a *team* (teachers and administrators from a school or school system).

FUNDING: Demonstration centers would require national funding but could possibly charge tuition for team training.

TARGET POPULATION: a) teachers and administrators for training. b) general public in terms of publicity for effective programs.

TIME PROJECTION: 1 year to establish (effect & upgrade) demonstration centers. Programs could then be continuous.

26. (36) Fund a project which would place a small computer at the disposal of a single elementary school. A program of individualized instruction would be instituted throughout the entire school. The computer would be employed to assist in helping the school implement the open, individualized setting. It would be concerned with branch testing for diagnostic and assessment purposes, with management information for the students and teachers, for making instructional decisions on the next steps to take, and would also be used for instructional purposes alongside standard teaching. This project would show the intensive use of a computer in a total school effort to redesign education.

FUNDING: $500,000 a year.

TARGET POPULATION: Elementary schools.

TIME PROJECTION: Six years.

27. (36, 37, 38) The design, testing and evaluation of an effective, practical and economically viable educational system on a prototype basis should be undertaken and financed by the Federal government – with congressional approval and a long term commitment to its successful completion. I would assume the cost of such a program at approximately $100,000,000 and the time required as 5 years.

28. (36, 37, 38) CAI cannot be demonstrated in a traditional school setting because no school is organized in ways which permit evaluation of the characteristics of CAI.

All of the operational characteristics of CAI which are cost effective outside of the educational setting turn out to be irrelevant in schools. The details to support this position are found in two very important articles: Randall & Blaschke "Educational Technology: Economics, Management and Public Policy," *Educational Technology*, June 30, 1968; pp. 5-13, and Kopstein "Why CAI Must Fail!", *Educational Technology*, March, 1970; pp. 51-53.

If these descriptions of the situation are accurate, then any further "demonstrations" of CAI in schools are pointless. Instead, we should be experimenting with our ability to organize and administer schools so that the characteristics of CAI can be measured. This would require designing a school from the ground up. It would entail developing an enormous body of curriculum before the first class could enter. The operation of such a new school would include the following features:

1) Each student would progress through the school as a function of the courses he completes regardless of the time he requires to do so.

2) Every course taught in the school will include some CAI elements, although the ratio to other course activities will vary widely from course to course.

3) Each course grade will depend at least partially on student performance on the CAI elements. There will be absolutely no pressures to grade on a curve for fear of ". . . giving too many A's."

29. (39) I just don't have a "master plan" for launching CAI to the benefit of 55 million students. Indeed, I don't even have a feeling for how much money would be needed to demonstrate that CAI could be a cost-effective means of educating many of these people.

My fear is that CAI, like the moving picture, the radio, and television, will ascend like a rocket, burn out, and descend to earth – just another device that held such early promise for better learning but could never work its way into the American schoolhouse and into the habits of the American teacher.

Let's face facts: Teachers possess the territory. Any device that suggests technological unemployment, or seriously alters professional practice, will encounter well-meaning hostility. Reception will improve in proportion to the extent that the teacher's capability is enlarged. To accomplish this the role of the teacher has to be changed and education, unlike business and industry, hasn't the resources and sometimes the inclination to retrain its people in any fundamental way.

Assuming that CAI can extend the teacher and increase his productivity, it is unfortunate that the costs of whatever is new become add-on costs, not trade-off costs. This is the dilemma and it may take years to switch from add-on to trade-off. In the long run, though, that is the hope. CAI must await the reorganization of education itself before a substantial market can be secured. As a target for early entry, I would guess that the American home will be a better market than the American school.

If I were pressed to designate what sector of education would be most responsive, I would say "the new towns." Over 200 new towns are now in some stage of planning or construction in this country. These new towns frequently have no history, no constituency, and no established ways. They are free to strike out on their own to teach their people – not just children – in more effective ways. A demonstration mounted in a new town can have credibility among the 17,000 school districts that, though autonomous, nevertheless desire to catch up with the state of the art once somebody has demonstrated it.

Forget the big cities – unless Federal funding is assured and sustained. Forget suburbia – they have enough money to buy the best teachers and run the smallest classes. Forget the hustings, for they are so close to marginal survival that any expenditure beyond textbooks and band uniforms is politically beyond their grasp.

The new towns though are reaching for better ways. In this setting, CAI has a chance to prove itself, especially if the learners are persons of all ages wherever they may be, and not just children locked for a few years in something called a schoolhouse.

Historically, education is a receiver, not an initiator of invention. With the coming of CATV and other ways of floating information from people who have it to people who want it, the prospects of CAI improve. As homes and businesses and people generally come to profit from CAI, the chances increase that CAI can get through the schoolhouse door.

Nothing in the above should be construed as placing the blame solely on education and educators. There is enough blame for everybody.

30. (41) Techniques for leasing or joint use by school groups might aid in reducing costs and providing adequate tests as to "cost effectiveness."

31. (48) Set up four or so regional centers in universities in different parts of the country. Each location should have 1) a timesharing system or systems available for large scale student use, 2) philosophy that encourages such use, 3) faculty members with strong discipline oriented backgrounds who have already begun to use computers in teaching and learning situations. Faculty, local and visiting, should be attached to the center for periods ranging from 6 months to 2 years, first developing materials (with no restrictions as to the type and amount of computer usage) for innovative approaches to their areas, and then using these in full classes and revising them based on this usage. Emphasis should be on modules usable in *or out* of ordinary classes, looking toward such concepts as the open university. Programming support, etc. would be provided, but the primary function would be to develop discipline oriented teaching materials rather than software. Each school should have an available general purpose computer, *different* in school to school. At least one of the groups should be oriented toward graphic terminals. Five year life, about 6 faculty members per location. Several national meetings each year involving all centers.

FUNDING: $200,000 for personnel, each location, each year, plus $30,000 for computer time and $50,000 for travel, etc. $280,000 x 4 centers x 5 years = about $6 million. Federal funding–O.E. and NSF.

TARGET POPULATION: Colleges, universities.

TIME PROJECTION: Five years.

32. (49) Set up training laboratories, possibly run jointly by teacher training institutions and textbook publishers (or the CAI equivalent), for authors and supporting technical teams.

FUNDING: Public and private, with industry subsidy.

TARGET POPULATION: –

TIME PROJECTION: Continuing.

33. (50) Establish a number of discipline-oriented centers for production of course materials that support the use of computing within the curriculum. Authors would come to the centers to work full time on production of materials. Centers would give editorial and programming assistance, salary, expenses. Centers would publish, advertise, distribute completed monographs, books, programs, etc. Centers would organize travelling circuses to take materials to schools and show them off. Centers would host training institutes for interested faculty.

FUNDING: $300,000 per year per center. Sources – mixture of Federal, professional societies, commercial publishers.

TARGET POPULATION: Teachers who decide course content and curricula at their institutions.

TIME PROJECTION: 3 - 5 years duration, starting now.

34. (51) Subsidize discipline-based groupings to develop curricular materials employing the computer extensively, but not exclusively. Begin with lower division courses in topics with large demands and high computer relevance; e.g., economics, business, engineering, computing, modern languages. Require that materials be developed in a way that enables wide-scale distribution. (Rely on activity described under action plan II to provide means of distribution – #22.) Arrange for royalty payments and credit to individual authors.

FUNDING: NSF, OE, NIE (when authorized): $1 million/year per subject.

TARGET POPULATION: Lower-division college students.

TIME PROJECTION: 3 - 5 years.

35. (51) I would proceed on two fronts. 1) The development of discipline task forces, or educational level task forces that would develop a CAI prototype in a particular field of work and proceed to demonstrate to their colleagues around the country the quality and feasibility of the endeavor. In short, build a better mousetrap and proselytize. This requires institutional cooperation and brownie-point recognition and probably must be done on an inter-institutional basis. 2) Seek general recognition of the priority status needed for the application of technology to education. Make quality education a national goal – like going to the moon.

FUNDING: Massive federal and foundation support perhaps coupled with tax incentives or other forms of subsidy.

TARGET POPULATION: Academic peer group for each taskforce.

TIME PROJECTION: 4 - 8 years.

36. (51) Support multi-disciplinary applications of the computer (areas such as social studies, science, business, industrial arts, mathematics). A team consisting of computer specialists, simulation specialists, and educators would work with master teachers to identify areas where the computer can be effectively used within the curriculum of the present and foreseeable future. Simulations and other activities would be developed that could easily be implemented to expand student horizons

FUNDING: NSF or OE – $200,000 per year.

TARGET POPULATION: All secondary students.

TIME PROJECTION: Five years.

37, (53, 61, 62) Establish incentives (and supporting procedures and resources) for more effective development, documentation and exchange of computer-related learning materials.

Establish standards for documentation (including validation).

Develop guidelines for development, testing, revision, exchange (e.g., using someone else's materials, perhaps with modifications).

Establish procedures for obtaining credit for materials development (clearinghouse, national index, reviewing procedures for professional journals, classification, etc.) with special attention to encouraging improvements in materials (a step up a ladder indicating quality and usefulness, reflecting academic records and opportunities for economic recompense).

Make it easy for one to find out about available materials (at different levels of tested usefulness), to try them out, to adapt them for local use, and to report results back into the clearinghouse data bank.

Feed the information and procedures of this national incentives system into the training programs, both in-service institutes and regular academic programs (including programs for teaching fellows in universities).

FUNDING: NSF and OE, $500,000 over three years.

TARGET POPULATION: Authors and users of computer-related curriculum materials.

TIME PROJECTION: Some small and favorable influence in first two years, beginning to show results in third year. Clearinghouse should become self-supporting, and standards and guidelines maintained by committees associated with professional societies and accreditation institutions, but some follow-on funding may be needed to carry forward effectively for a few years.

38. (54) To produce a thorough revision of the content of education is a major intellectual undertaking. It will happen – and indeed, in a small way is happening. But its rate of progress will depend unpredictably on its ability to fire the imagination of creative, energetic people. Unfortunately this is not happening except in a desultory fashion. "C.A.I." as an area of intellectual endeavor has a public image of drabness and mediocrity. This is certainly a most important factor responsible for inhibiting the widespread use of computers in education. I believe that the most effective action that could be taken now is to create conditions for research that will stand some chance (there can be no guarantee!) of competing with the more "glamorous" areas of intellectual endeavor for people of the highest caliber.

An example of a practical step in this direction is creating a research institute (or several!) with facilities for several experiments on the scale of providing groups of children with unlimited access to computers over a period of several years, of freely experimenting with new computer controlled devices, of being able to set up teams of trained observers to track the progress of individual children, and so on. It is important that such an institute be able to separate the pursuit of fundamental knowledge from the economic and practical problems of applying the outcome of its research on a large scale. It is important that it have the means to attract visiting scholars, graduate students and, of course, its own faculty. To do this would cost between seven and ten million dollars for the first five years, which I see as the minimum viable period for guaranteed support.

I strongly suggest that the EDUCOM study should propose the creation of 1 or 2 such institutes, and should immediately concentrate on sponsoring the production of several detailed proposals for discussion.

39. (54,55,66) Establish an Interdisciplinary Center for Educational Development and Change in which CAI would be used in its own instructional programs (extensively but not exclusively) and with special emphasis given to the use of computer-based systems as instruments for change in curriculum, the role of the staff (especially the teachers) and in the assessment of individual development. The three training programs would be: (1) team training of interdisciplinary teams in the complete development cycle (planning through summative evaluation) for instructional program development; (2) individual training of managers of development and delivery systems for instructional applications; and (3) individual training of evaluators and researchers in the evaluation process from planning to summative evaluation, including testing and data processing, not only for personnel evaluation but also for cost-benefit analysis of systems and approaches. All three programs would be run concurrently and would continue throughout each year. While each would have its own primary staff, some personnel would be shared to achieve economies. Administration of the center would

be in the Division of Educational Research and Development, SUNY at Stony Brook, which, among other administrative units, has an IRC (Instructional Resources Center) for materials development and with its dedicated CAI system, a Center for Continuing Education which offers courses at the graduate level to the community, and a Department of Education. Harvard case study approach would be used extensively.

FUNDING: USOE Personnel Development and US Public Health, Manpower. $200,000 per year for 24 students (8 per program).

TIME PROJECTION: Seven years with 24 the first year and modest increments in the numbers in succeeding years resulting in training approximately 175 people at the masters level and approximately 20 in all three programs for doctoral level which also would include a dissertation. Since only 3 to 5 would recycle from each graduating class, there would be approximately 20 people available for employment each year.

40. (56) There is abundant evidence that CAI in its various forms can effectively contribute to college, post-graduate and professional education. In institutions of higher education, failure to conduct more broadly significant and effective CAI innovations has been in considerable part due to lack of faculty incentive. This lack of incentive results from a variety of factors and is evidenced in many aspects of faculty endeavor.

1) *Lack of reward.* Most of the lack of progress in educational innovation and improvement results from this cause. In contemporary academia, the faculty comprising the major universities receive very little professional, economic, career, or personal status reward for teaching; particularly undergraduate teaching. Despite virtuous – and entirely sincere – declarations on the part of both the faculty and the administration to increase the valuation of teaching in appointment and promotion procedures, little revision actually occurs. Inertia and difficulty of objective evaluation are of small significance in explaining this failure compared to the national ambience within the academic community which decrees that research and scholarly activity recognized on an international scale are the only significant indices of professional success. Until this generally pervasive value system is modified, no single institution, however prestigious, can by decree greatly redirect the activities of its faculty.
2) *Lack of knowledge.* Most of the faculty comprising the major universities are professional scholars, but amateur teachers. They have had no education in the field of education except the experience of their own education. Furthermore, they generally – and not without some justification – disdain the organized discipline of "Education" as represented by traditional Schools of Education. Most faculty tend to perpetuate the historical techniques and intuitive convictions characteristic of their own education because they are largely unaware of that body of knowledge from which they could rationally design more effective and efficient educational programs.

   An example of one of the more defeating convictions among some faculty is the belief in the essential mysticism of the educational process; that a mysterious effluvium flows from the teacher to the student through which the student acquires the most significant elements of his education. This effluvium can, apparently, only be transmitted through air and across short distances. It is blocked by any mechanical or electronic contrivance and also is destroyed by any attempt to analyze the student's educational goals and needs in terms of his eventual role in society. This concept inhibits more rational attempts to define educational goals in operational terms, and prepare programs and tests to accomplish these goals most effectively and efficiently.
3) *Lack of leadership.* Since very few rewards accrue to the full time dedicated undergraduate teacher, creative, charismatic leadership does not arise. In addition, it is a cherished conviction among most faculty that each is equally expert in the educational process; or at least that each must be allowed to pursue his individual convictions toward the instructional process.

Nevertheless, the faculties of the nation's universities comprise a primary resource of expertise necessary for the development of CAI, and the universities themselves are fertile sites for testing various types of CAI programs. Universities often have primary and secondary level "laboratory schools" associated with their departments of Education in addition to their college, graduate and professional academic programs. Many universities already have sizeable computer facilities and large numbers of personnel skilled in all aspects of computer use and design. The primary need is to engage a sufficient number of appropriate faculty in CAI development as a first priority task. With a few notable exceptions CAI experiments within universities have been desultory and disappointing, due to general faculty apathy and lack of reward.

To modify this situation will be difficult, but I propose that Federal grants be made available to universities – not to individual faculty members – for CAI research and development and that their use be rigorously subject to the following requirements:

1) First priority commitment of an interdisciplinary group of faculty to project. Grant should provide salary support for these faculty and require full time commitment (with full time salary support) from principals.
2) Guarantee from the University that the faculty involved in this project will have their project related work evaluated for promotion as equivalent to scholarly contributions in a conventional discipline.

FUNDING: Grant amounts would vary according to project, but to insure a sufficient magnitude of commitment, $500,000 per year for a period of three to five years should not be considered excessive.

TARGET POPULATION: Varies with project from primary and secondary level to professional.

TIME PROJECTION: Varies with project up to five years.

41. (63,64) Experiment with and refine the technological capabilities of the three computer system approaches that offer a chance of promoting inter-campus exchange of instructional materials:

1) centralized time-sharing systems
2) decentralized minicomputers with cassette programs
3) networks with 2) as terminals communicating as access with 1).

Emphasize the requirements for exchangeability of materials!

FUNDING: NSF, State HE Authorities, OE, National Institute of Education (if authorized). $1-10 million for development. Some operating subsidies, but most costs should be covered by schools.

TARGET POPULATION: Higher education.

TIME PROJECTION: 2 - 5 years.

42. (67) I do not think the evidence warrants any actions to further the growth of CAI.

43. (67) WAIT. DO NOTHING. Institutions which see a need will proceed if they can find a way. Let them compete for funds that are *not* earmarked for CAI. Where problems are soluble they will merit investment and will get it. There are too many *uncontrollable* forces at work – too many proven educational projects and products which deserve funding ahead of CAI.

44 (71) All too often research and development work in CAI has failed to distinguish between two basic issues: the first is adapting the computer to the needs of education and, second, improving educational processes, now possible through the use of computers. Unfortunately, the first issue has often been overlooked in favor of the second. We have attempted to address the issue by saying, "now that we have the computer, we can save education." This is definitely not a realistic approach. Early

uses of the computer in other industries altered the process of those industries at most only slightly. Only after a great deal of experience with computers existed and after many processes were implemented on a wide scale with computers, were basic changes instituted. A good example is the banking industry. Even today after a decade and a half of the use of computers on a wide scale, demand deposit accounting, still remains much the same, with the checkless and cashless society remaining a futuristic idea. The analogy in education suggests that we are guilty of trying to implement the cashless and checkless society rather than first simply trying to adapt the computer to the needs of education as we now know it. Emphasis, therefore, should be placed upon accepting the various aspects of education as they now are, and using the computer to improve the present processes. Where the computer can be used as an aid to the teacher or administrator, this should be explored. If drill and practice can be done by a computer in a way that directly aids the current process, this should be explored. In short, I suggest that emphasis be placed upon accepting pedagogy as it is today and upon using the computer to aid the present processes rather than emphasizing the redesigning of education so that it will best fit the computer.

45. (73) One of the basic problems with the acceptance of CAI on a wide scale in education is that CAI systems to date have largely been designed for a relatively small number of students or for research purposes or both. It is now necessary that a "production outlook" be adopted. That is, research and development should concentrate on serving the needs of a large number of students with much more efficient systems. This must be done even if some flexibility is sacrificed. Educational researchers tend to concentrate on pedagogy and very careful evaluation of educational approach. Much of this work has been done and documented as it relates to CAI. On the other hand, very little work has been done with those in education that have the "production" education problem. Emphasis, therefore, should be placed upon relating future development activity directly to the problems of the "production" educator. Superintendents of schools of large cities and administrators of community colleges are both good examples of individuals with "production" education problems.

> FUNDING: Since what is being recommended here is a matter of emphasis rather than specific projects, there is little or no funding required. Ideally, this emphasis should be placed upon the educational community by the US Commissioner of Education. This emphasis can be supplemented by reports in educational journals, and other publications.
>
> TARGET POPULATION: Educators, educational publishers, and those involved with educational applications in the computing industry.
>
> TIME PROJECTION: Immediately with period reinforcement in the future.

46. (76) Any attempt to program for tutorial or dialogue CAI quickly runs into the difficulties of processing students inputs – responses or questions – expressed in natural language. Ideally, the CAI course author should be able to pose a question to the student, specify a model answer, and instruct the processor to accept as correct that answer, or *any answer whose meaning is the same.* What is needed is the development of a program which will perform this semantic analysis and provide the CAI processor with the result.

While this is a formidable requirement, the implementation of any approximation to it would constitute a significant breakthrough for CAI. It would allow us for the first time to lift the various artificial restrictions on student inputs which only degrade the teaching effectiveness, and limit the scope, of CAI programs.

> FUNDING: On this and the time projection, an expert in linguistic analysis should be consulted. Bernard Spolsky, Indiana University, was deep into this problem in 1965, and could provide a far more accurate projection.
>
> TARGET POPULATION: Not too critical; 8th grade or over.

47. (76) A general program of grant support is needed for development of CAI techniques, especially those devoted to providing more latitude for the student. Proposals would be evaluated in typical fashion. The emphasis would be on enhancing the capabilities of the computer (which has often been called artifical intelligence, an awkward term).

FUNDING: NSF Office of Computer Activities – Initially ½ million per year.

TARGET POPULATION: Applicants would probably be from universities and research laboratories.

TIME PROJECTION: Indefinite – 10 years at least.

48. (77) A number of recent studies have begun to yield results in CMI. Here instead of the computer directly interacting with the student, the computer is used as an aid to the teacher, usually in the normal teaching process. Several computer guidance counselling systems have been designed and are operating. More than 20 different unrelated efforts are underway experimenting with the use of data banks. These data banks contain test questions or lesson planning material or, simply, resources. In the use of test question data banks, for example, quite elaborate systems have been designed to enable the fully automatic preparation of tests, the grading of these tests and the maintenance of statistical results. Our primary interest in all of these examples is the fact that the cost per student is much lower than is true in tutorial and drill and practice CAI. In some cases, the cost difference is as much as two orders of magnitude. A task force should be established, probably by the US Office of Education, to develop a strategy for the thorough exploration and development of CMI applications and to coordinate the implementation of this strategy.

FUNDING: Funding for these projects should continue to be the responsibility of those undertaking them. This is true of both industrial and educational institutions. Where joint studies are desired, each participant should fund his own portion of the effort. The strategy task force and coordination effort recommended above should probably be the responsiblity

TARGET POPULATION: Since, by definition, Computer Managed Instruction is designed to aid teachers, the target population is teachers and instructors at all levels of education.

TIME PROJECTION: The strategy and coordination effort proposed above should be begun immediately. By the end of its first year, it should have succeeded in identifying existing projects and recommending new projects to cover the wide range of computer applications possible. Since cost constraints are so much less severe than in most of today's CAI applications, it is my belief that the market exists now for CMI applications.

49. (78,79,81) Organize project to develop one or several educationally oriented terminals:

1) As *inexpensive* a terminal as possible–using existing technology and production wherever possible, planning on the basis of large-scale use in the future.
2) *General purpose* terminals, for use of existing general purpose computers – 8 bit code, ASCII, etc.
3) Many options – *graphics,* slides, audio, tablets.
4) *Variable character set,* controllable in program. Every area has its own symbolic requirements. Authors should be able to use *any* characters needed for natural presentation of material.
5) Hardcopy options for *groups* of graphic terminals.
6) *Great* attention given to physical *design* of terminal and associated environment to make it as effective as possible in the teaching situation. Use very competent industrial designers with long-range interest in design/education interaction, such as Charles Eames. Should include design of rooms for groups of terminals and associated devices, such as hard copy.

Design team should involve industrial designers, innovative engineers, teachers students, use market analysis techniques to test preliminary designs with a wide range of students.

FUNDING: Try to obtain support from a group of vendors – manufacturers, distributors.

TARGET POPULATION: All educational users.

TIME PROJECTION: Five years.

50. (78) Many, if not most, computer assisted instruction programs actually utilize only a tiny fraction of the capacity of the central computers by which they are serviced, which involves wasted expense. If there were available access to an adequate data bank and encoded programs in other forms, an extremely simple digital computer could perform the necessary operations in receiving and interpreting the student's responses and in selecting for display or other transmission the next instructional unit or sequence. It might be possible to build such a limited computer capacity into a self-contained terminal having both CRT and keyboard facilities, and provide access to a data bank by continuous retransmission of the data banks content by cable. The total content of an adequately large data bank could be circulated dozens of times a minute by cable, so that the computer unit in the terminal could select the needed elements almost instantly.

This is beyond my expertise, but I am told that such a terminal and system are theoretically quite practicable. If they could be developed, it would permit CAI uses in institutions without access to expensive central computer installations and would greatly increase the range and flexibility of the techniques.

The project would be a research contract by the Federal Office of Education with a firm competent to design, create, and test the proposed hardware and system.

FUNDING: Federal. I am not in a position to make an informal judgment as to amount, but I would guess for research development, and testing expenses through the production of a working prototype it would be on the order of $500,000.

TARGET POPULATION: General.

TIME PROJECTION: Three years.

51. (80) The combination of cable TV plus time-sharing computers plus specially designed terminals has already been demonstrated to be cost-effective. The work is, however, so far only in its beginning stages of development. Several R & D efforts should be studied to design the best combination of equipment for both institutional and home use. An appropriate team might consist of a computer specialist, a communication technologist, a systems engineer, and an educational expert.

FUNDING: Office of Education, NSF – $1,000,000 for up to four beginning efforts.

TARGET POPULATION: –

TIME PROJECTION: 1 - 5 years.

52. (82,83) Several research and development projects should be established aimed at the possible redesign of drill and practice and tutorial CAI. Projects should include:

1) Thorough systems analysis of CAI as it might apply to large numbers of students without completely altering today's education systems. Emphasis should be placed upon minimizing system cost if necessary at the expense of flexibility and added function.

2) The design of those special computer terminal features required by education and more or less unique to education. These include random access audio capability for use in teaching reading and languages and computer controlled video cassette capability to lower the cost of storing and presenting large quantities of educational material.
3) A task force made up of representatives of the computer industry, the publishing industry, and education should be convened to address the materials of instruction problem. This effort should be coordinated with the redesign of CAI outlined above and should be charged with determining responsibilities of each of the three institutions represented in successfully making available quality materials of instruction.

FUNDING: Funding and staffing of the above projects should be the responsibility of those who see them as justifiable on a business basis. Projects which relate to the computer industry should be staffed and funded by companies involved. Educational participation will probably only be justified by larger school institutions, educational research centers and universities. Leadership and coordination should be provided by the US Office of Education. Where joint studies between companies and educational institutions are warranted, they should be encouraged. But in such joint studies, each participant should fund his own expenses. Special subsidies will only serve to produce unrealistic results from a business viewpoint.

TARGET POPULATION: While the broad spectrum of all students is included in the target population here, this can be narrowed to only elementary schools if desired. It is my belief that if the CAI problem can be solved for elementary schools (particularly from the standpoint of cost) the solution is easily adaptable to the rest of education.

TIME PROJECTION: The projects outlined above will typically require one to two years to reach conclusion. The modifications to CAI should be planned to meet the cost constraints expected in education in the 1975-80 timeframe.

53. (83) Very necessary for work in elementary schools are inexpensive, versatile consoles (student stations). An intensive effort should be undertaken to design a commercially feasible random access to audio and visual displays. In elementary schools, the storage capacity need not be very great; but inexpensive access to a limited set of displays would be highly desirable.

FUNDING: Industry – $75,000 a year for three years.

TARGET POPULATION: Elementary schools.

TIME PROJECTION: Three years.

Appendix 5

Action Statements

Following are the 83 action statements compiled for the conference from the questionnaire data, plus the additional statements which were suggested and included for consideration during the conference.

1. Large-scale Demo

Mount a large-scale experiment to demonstrate the economic feasibility of CAI.

2. Mobile Demo

Institute a mobile demonstration that could travel from school to school, carrying terminals, plotters, minicomputers, and data acquisition equipment, and provide thorough and realistic demonstrations of how teachers use computers in their courses.

3. Labs as Showcases

Use existing facilities and labs not only to implement CAI ideas but also as showcases for demonstrating successful CAI techniques.

4. Demo – Non-educational Sector

Demonstrate the efficacy of a large-scale CAI system in the military, governmental, or private sector to ease its acceptance into the educational community.

5. Cooperative Project

Implement a cooperative project involving a community college system and a major commercial producer of educational materials to develop, test, and demonstrate a remedial course in English.

6. Adjunct Systems

Concentrate on development of adjunct CAI systems in limited areas of concern, e.g., science laboratory work, rather than main-line general systems.

7. Reading – Elementary School

Organize a national effort to create two or three alternative CAI programs aimed at the correction of reading deficiencies in elementary school children.

8. Reading – Young Adults

Implement a reading improvement program for young adults that could be run as a remedial, open-enrollment city university program.

9. Remedial Math

Develop a computer-managed system of instruction in remedial mathematics for grades 7-12.

10. Disadvantaged

Focus a CAI program on reducing inequities in the education of disadvantaged children.

11. Rapid and Slow Learners

Develop special CAI programs for both rapid and slow learners at all levels.

12. The Deaf

Develop courseware for teaching the deaf to read and write.

13. High School Opportunities

Provide opportunities for high school students to work with computers in their own instruction through participation in the production of hardware and the development of curriculum materials.

14. Job Corpsmen

Develop an experimental program to prepare talented job corpsmen in the fundamentals of computer technology.

15. Para-professional

Organize a national effort to create a computer-assisted course in a selected para-professional subject (e.g., X-ray techniques, police management, assistance programs for the aged).

16. Unemployed

Subsidize industry to develop CAI packages for retraining unemployed workers.

17. Group Instruction

Experiment with the application of CAI to group instruction in addition to individual instruction.

18. Classroom Games

Develop computer-based games to provide structured interaction between different classrooms in the same, or different, schools.

19. Simulation and Gaming

Concentrate curriculum development efforts on utilization of the computer's unique capabilities, e.g., in problem-solving exercises, simulation, and gaming.

20. Cooperative/Competitive

Develop programs in which the student questions the computer rather than the reverse (cooperative rather than competitive use of the computer in a learning situation).

21. Learning Styles

Develop the capability to identify and match student learning styles in different content areas with appropriate pedagogical techniques.

22. Learner Control

Develop systems that allow more learner control of the material and of the style of teaching.

23. CAI Learning Models

Develop a model of the learning process that provides insight into the uses of CAI (rather than a general-purpose model).

24. Learning Theories

Develop a foundation of theories of learning and experimental data which would enable the computer to be maximally flexible and effective in teaching, as opposed to being a page-turning and response-recording device.

25. CAI Modules

Develop methodologies and techniques to support organization of course material into modules that can be utilized in CAI systems.

26. Special Ed. Problems

Develop courseware to train teachers to identify special education problems and to prescribe appropriate remediation.

27. Support Teachers in CAI Development

Identify teachers who are good writers and who have classroom experience in computer applications and support them in the writing, publishing, and distribution of quality curricular materials.

28. Finance Teaching of CAI Techniques

Finance teacher training institutions to include practical training in the use of hardware and software, and in the techniques of integrating CAI with the traditional education process.

29. Summer Workshops

Institute summer workshops to provide teachers with hands-on experience with available CAI systems.

30. Incentives for Teacher-Training

Offer financial incentives for teachers to take training courses in the use of CAI.

31. Training in Technology

Develop through NIE an agency to train teachers in instructional technology, including capabilities and limitations of processing systems and design, development, installation, and evaluation of self-instructional materials.

32. Individually Prescribed Instruction

Provide courses in individually prescribed instruction and small-group tutoring in schools of education, thereby providing teachers with a background more appropriate to CAI.

33. Instructional and Management Support

Design a computer-based system which would provide support for all of the instructional and management functions in a school system.

34. Train Administrators

Implement a program of systematic dissemination and training in CAI applications for school administrators.

35. Model for Administrators

Develop a computer-based, interactive model for school administrators that shows how schools can incorporate CAI, at what cost, and at what savings.

36. Model Elementary School

Set up one or more CAI-based model elementary schools.

37. Model High School

Set up one or more CAI-based model high schools.

38. Model College

Set up one or more CAI-based college campuses.

39. Model Town

Set up a large-scale model demonstration of CAI-in-the-home in a new town (200 new towns are now in some stage of planning or construction in the U.S.)

40. Summer/Evening Instruction

Exploit the opportunity for individualized instruction during summer and evening hours.

41. Cost-Sharing

Develop cost-sharing programs for school districts and learning centers installing computer-based instructional programs.

42. Budgeting Cycle

Revise year-to-year budgeting for operating expenses so that school systems can be better prepared to finance substantial capital investments.

43. Lock-Step

Produce and test alternatives to lock-step procedures to accommodate differences in learning speed and in curriculum selection.

44. Community Coordinators

Establish model community agencies for coordinating CAI applications in urban school systems.

45. Private Investment

Permit private investment to provide the capital for schools interested in implementing CAI systems.

46. Private Development

Implement a liberal policy of support for private equipment and software development organizations.

47. Tax Incentives

Provide tax incentives for industrial investment in CAI development.

48. Regional Centers

Establish regional centers with local and visiting faculty to develop materials and to use and revise them in classroom applications.

49. Joint Laboratories

Set up CAI laboratories for authors and supporting technical teams, to be run jointly by teacher training institutions and textbook publishers.

50. Discipline-Oriented Centers

Establish a number of discipline-oriented centers for production of course materials that support the use of computing within the curriculum.

51. Discipline Task Forces

Develop discipline or educational level task forces to develop a CAI prototype in a particular field and to demonstrate the quality and feasibility of the endeavor.

52. Discipline-Based Standards

Fund committees and review panels within disciplines to encourage the establishment and application of discipline-based standards.

53. National Clearinghouse

Establish a national clearinghouse for the collection and distribution of CAI materials.

54. Research Institutes

Set up research institutes and quality training programs to attract people of high intellectual calibre to CAI field.

55. Graduate Programs in Teaching

Establish graduate programs oriented toward teaching rather than research, as a first step toward quality education, including CAI development.

56. Professional Incentives

Establish professional incentives for university faculty through a grant program that requires from the recipient university assurance that work on CAI development would be judged equivalent to research, in terms of promotion, salary, etc.

57. Exchange of Professionals

Introduce a system of exchanges of CAI professionals among industry, government, schools and universities.

58. Professional Journal

Publish a first-rate professional journal solely for the instructional uses of computers.

59. Annual Award

Offer annual national awards for the best CAI programs.

60. Copyrights

Develop copyright procedures to protect CAI products.

61. Royalty Payments

Arrange for royalty payments and credit to individual authors for CAI curriculum development.

62. Publisher Fees

Create "market" for CAI materials by providing mechanisms and incentives (e.g., publisher fees) for program production, distribution, and use.

63. Hardware Standards

Develop national standards for equipment to insure interchangeability of curriculum packages.

64. Software Format

Establish a format for the production of software that will make it usable in a variety of hardware systems.

65. CAI Languages

Improve the efficiency of writing CAI programs by the development of better CAI languages.

66. Instructional Designers

Train instructional designers to supplement the work of CAI authors and production personnel.

67. Continuing Evaluation

Develop a continuing program for evaluation of CAI programs, techniques, curricula, administration, and organization.

68. Evaluation Systems

Set up a comprehensive research program to test a variety of CAI-based evaluation systems at school and college levels, possibly including performance in simulation exercises and educational games as a rating device.

69. Cost-Evaluation Studies

Conduct detailed evaluation studies that provide the data needed by school administrators to justify the introduction of new capital-intensive equipment and techniques.

70. "Benchmarks"

Identify the full range of CAI system requirements and develop "benchmarks" to measure progress and to assess effective management.

71. CAI Barriers

Institute a comprehensive research program to identify barriers to the introduction of CAI and to determine the changes which might contribute to their removal.

72. CPU Cost

Reduce the cost of central processor time to the neighborhood of 20 cents per student/contact hour.

73. Hardware Development Costs

Concentrate on reducing basic hardware and software development costs so that CAI, as a consequence, can become cost-justified.

74. Hardware Interface

Support research to identify the relative importance of keyboards, C.R.T. displays, accessory audio-visual devices, etc.

75. Computer Design

Design computer logic and architecture appropriate to the primarily non-numeric processing demands of CAI.

76. Semantic Analysis

Develop software to perform semantic analysis for processing student inputs expressed in natural language.

77. Integrate Media

Design a CAI system that integrates a number of instructional modes and media.

78. Educational Terminal

Organize a team of industrial designers, engineers, teachers, and students to develop one or several educationally oriented computer terminals.

79. Communications Equipment

Utilize existing communications equipment, e.g., television, telephone, electric typewriters, to produce cost breakthroughs in CAI.

80. Cable TV

Combine large time-sharing computers and cable TV with appropriate terminals to produce lower costs.

81. Graphics Capability

Develop student terminals that offer a graphics capability.

82. Videotape Cassettes

Develop a computer terminal which can utilize videotape cassettes.

83. Audio Unit

Develop a computer-controlled random access audio unit for use in teaching reading and languages.

Additional action statements resulting from the conference discussion:

84. The Blind

Develop courseware for the blind. Braille terminals exist and Braille also can be produced by a terminal.

85. Investigator-Reporter

Fund a single, highly competent investigator-reporter to survey the whole field and report on its present state and prospects in the clarifying, framesetting way done, e.g., by Jean Chall in *The Teaching of Reading.*

86. Health Sciences

Develop a national center for the health sciences.

87. Programming Courses

Teach programming (Fortran?) as part of the core curriculum.

88. Feedback From Schools

Obtain feedback from school personnel on the factors which impede the implementation of CAI in the schools. (Include teachers, administrators, school board members, and various "minorities".)

89. Non-Science Majors

Teach a course on computers for non-science majors.

90. "Sesame St."

Fund "Sesame St." type curriculum development projects for CATV distributed CAI. Effective, efficient, and palatable instruction.